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RESEARCH ON FORAGE PLANTS AT THE AGRICULTURAL EXPERIMENT
STATION IN BARI

BY

E. PANTANELLI.

DIRECTOR.

A prominent task of the Stazione Agraria Sperimentale in Bari (established 1919) is research work on forage plants and fodders suitable to the hot, dry climate of South-eastern Italy. In Apulia, for instance, rainfall fluctuates mostly between 400 and 600 mm., but three-quarters of this amount fall between October and April.

When this work was started (1921) it was the general opinion that no forage production was possible in this section of the country without irrigation and that practically nothing could be done for the improvement of pastures. A few attempts to grow lucerne—the prominent forage of Central Italy—had been a failure. We have attacked the problem from many aspects and by twelve years' work we have secured the following results.

1. *Pasture improvement.*

An experimental pasture was established in 1922 at Cassano (Bari) on rocky calcareous soil, at a height of 420 m. above sea level, together with several trials on private grounds in the great plain (Tavoliere) of Foggia.

On the rocky hills, top-dressing with superphosphate and nitrate has proved insufficient to improve the natural flora owing to the lack of good seeds. On the better soils of the plain, broadcasting of superphosphate and ground limestone has brought a real improvement by restoring the leguminous components of the sole.

The renewing of the sole by light ploughing, dressing and seeding of grasses and clovers has given no result, because it enhances weed development and it takes several years to restore a carpet of good pasture plants.

A marked improvement has been obtained by removing stones, weeds, bushes and sowing the cleaned areas with good forage species. The best results have been secured with native annuals, like *Trifolium stellatum*, *Anthyllis rubra*, *Lotus ornithopodioides*, *Melilotus sulcata*, *Astragalus humosus*, *Medicago arabica* (and other annual species of *Medicago*), *Phalaris media*, *Lolium rigidum*, *Avena fatua* and with perennials like lucerne, lupinella (esparsette), sweet clover, sulla (*Hedysarum coronarium*), *Psoralea bituminosa*, *Milium (Oryzopsis) multiflorum*. To ensure a permanent improvement, grazing must be suspended at the flowering stage (April-May) by enclosure and rotational grazing.

Such improved pastures are top-dressed every year with 2 Q.* superphosphate per ha. on calcareous ground, with superphosphate every year and 10 Q. limestone dust every three years on lime-poor soils.

The carrying capacity has increased from 100 to 125 sheep every "carro" (about 25 ha.) on rocky ground, and from 100 to 150 sheep on better soils.

2. *Spring herbage.*

The mild winter of Southern Italy allows a very early forage production through so-called "ferrane" or winter herbage (erbai). Barley, oats, vetch, crimson clover, fenugreek and small horse bean (favetta) have been used since the old times, but only on little plots for cutting green fodder in April or May. We have studied from 1921 to 1925 the characteristics, ecology, chemistry, adaptation and cultural needs of these crops, which can yield from 150 to 400 Q. green fodder per ha. by proper culture. Mixtures of vetch (100) and oats (30) or crimson clover (30) and oats (30) can be sown for hay.

* Quintal = 100 kg = 220.45 lb.

Trials were made also with Bersim (*Trifolium alexandrinum*), *Medicago lupulina*, *Anthyllis rubra*, *Trifolium stellatum*, *T. suaveolens*, *Trigonella corniculata*, *Ornithopus sativus*, *Lotus ornithopodioides*, *L. tetragonolobus*, *Astragalus boeticus*, *Melilotus sulcata*, *M. indica*, *Vicia ervilia*, *V. narbonensis*, *V. villosa*, *V. cracca*, *Phalaris media*, *Galega officinalis*, but none of these reaches the production of the afore-mentioned crops; some have special soil or climatic requirements which prevent a more general spread.

The work of the Station has been made known by Extension Offices (Cattedre Ambulanti di Agricoltura) and it may be regarded as a consequence of our work that the area under annual hay crops has risen, in the zone under our influence, from 86,100 to 105,519 ha., and the production from 1,782,000 to 3,244,800 Q. of hay from 1919 to 1931 (Official statistics). The study of soil conditions has led us to infer that this surface can be quadrupled.

3. Perennial meadows.

We have tested since 1921 the culture of perennial legumes, which had been discarded by former investigators. Tests were made with lucerne, red clover, lupinella, sulla, ginestrino (*Lotus corniculatus*), sweet clover, *Psoralea bituminosa*, *Medicago falcata*, *Anthyllis vulneraria*, but good results were generally obtained only with lucerne; sulla on clay soils and lupinella on shallow lime soils, have proved quite satisfactory for biennial meadows.

We have elaborated a method for growing lucerne without irrigation, which consists in: (1) good preparation of the seed bed by deep ploughing in September and harrowing in the late autumn; (2) dressing with superphosphate and, if necessary, with lime, avoiding stable manure; (3) drilling in February 40-50 kg. lucerne seed, without cover crop, in rows 30-40 cm. apart, according to the local rainfall; (4) in the first year, careful destruction of weeds by cultivation after the first cut; (5) commencing pasturing from the second year in the dry season and in the winter; (6) cultivating between the rows after the winter pasture; (7) dressing with superphosphate and sulphate of potash in alternate years.

This method of growing lucerne differs in some points from the traditional one. In semi-arid conditions, lucerne thrives slowly in the first year; the cuts begin usually in the first autumn, while full development is reached only in the third year. Therefore, the stand must be kept pure and high-yielding for several years. We have twelve-year-old lucerne in full production. Usually, the duration can be fixed at six years, which alternate with two triennial rotations.

Organic and nitrogenous fertilizers must be avoided, since they promote weeds [Bermuda grass, bromes, wild oats and barley, annual rye grass, smartweed (*Polygonum aviculare*), etc.] and prevent good nodulation. Potash must be liberally employed, and lime on soils with pH lower than 7. Nodulation on lucerne is extremely well developed in coarse, well-drained limestone soils; the residual value of turned-under lucerne stands can still be traced on the third after-crop.

Cuts must be made at the first bloom stage; pasturing in mid-summer and in the winter is necessary to prevent drought and cold damage.

Usually we gather two cuts and have a four months' pasture in zones with 400-500 mm., three cuts and a six months' pasture in zones with 500-600 mm. of rain. On good soil there may be expected a total annual production of 75 and 100 Q. lucerne hay per ha., respectively.

Our method is spreading and makes it possible to grow lucerne and other perennial legumes in the drier sections of Southern Italy. The surface of perennial sown meadows has increased in twelve years from 23,000 to 41,540 ha., the production from 736,000 to 1,714,860 Q. hay in our zone.

4. Irrigated meadows.

Irrigation experiment fields were established in Bari (1922), Foggia (1926), and Ofantino (1928) by pumping underground water from a depth of 10-12 meters. Under the conditions which are prevalent in this region, irrigation of meadows is economic only where the rainfall from June 1st to August 31st does not reach 90 mm. Lucerne is preferable to clovers on account of its persistence and yielding capacity. Red clover

or Egyptian clover can, however, be useful under irrigation for winter production.

The best irrigation method is the corrugation, with level ridges as wide as the blade-width of the cutting machine. Overhead sprinkling of lucerne has proved more profitable at Bari (580 mm. of rainfall) than at Foggia (470 mm.).

Irrigated meadows must be liberally dressed with farmyard manure, superphosphate, potash and lime, or gypsum every year. A maximum increase of 90 Q. lucerne hay per ha. has been secured by irrigation.

5. Summer herbage.

For drought resistant summer annuals, we have tested *Pennisetum spicatum*, *P. purpureum*, *Eragrostis abyssinica*, *Eleusine coracana*, *E. indica*, *Chloris gayana*, *Panicum frumentaceum*, *P. maximum*, *P. germanicum*, *P. caucasicum*, *Paspalum dilatatum*, *Anthistiria avenacea*, *Phalaris bulbosa*, *Sorghum halepense*, *S. exiguum* (Sudan grass), *S. vulgare*, *Helianthus tuberosus*, *H. annuus*, *Chenopodium quinoa*, *Vigna sinensis* (several varieties), *V. unguiculata*, *Soja hispida* (several varieties), *Phaseolus mungo*, *P. aconitifolius*, *Mucuna pruriens*, *Dolichos lablab*, *D. biflorus*, *Crotalaria juncea* (several varieties), *Cyanopsis psoraloides* (several varieties), *Cajanus indicus*, *Sesbania aculeata*, *Lespedeza japonica*, *L. striata*, *Euchlaena mexicana*.

The best results are obtained with Navajo Mexican corn, Early Amber sorghum, Sudan grass, Clay cowpea, black (Peking), brown (Nepal) and Mammoth Yellow soy bean. These varieties can be grown without irrigation, where the annual rainfall exceeds 550 and the summer rainfall 90 mm., on autumn-ploughed and manured, deep, mild soils.

A green yield of 80-120 Q. with the legumes, and of 100-200 Q. with corn and sorghum varieties can be obtained.

Irrigation permits the extension of the summer herbage in sections with poorer rainfall, like the Foggia plain, and makes it possible to obtain 100-150 Q. from the legumes, and 400-800 Q. from sorghum and corn varieties. Under irrigation, Caragua Dent and Singletons Strawberry are preferred to Navajo corn.

The leguminous summer herbage, which occupies the land from April to September, serves as an excellent seed-bed preparation for wheat.

6. Silage.

Our station has been the first in Southern Italy to assert the utility and study the practice of making concrete silos and ensiling southern crops. Many crops were tested for silage and it was found that little horse bean (favetta) and oats, crimson clover and barley, lucerne, sulla, corn and sweet sorghum give the best results.

At present the practice of silage is spreading in the southern provinces and when used for winter herbage is much more profitable than hay making. Favetta and oats are the chief silage; they are grown, harvested and ensiled together, in the proportion of one part oats to three parts bean seed. Sulla is stored alone on account of its high percentage of carbohydrates and fibre; lucerne is ensiled with straw or corn stalks.

The silo type commonly used is the "cremasco" or "Samarani" silo with movable cover; it has reached a good stage of perfection and is preferable for many reasons to the American silo; the protein loss is insignificant, the production of acid very low, the digestibility of all nutrients considerably improved and the capacity of the silo increased. It yields so-called "hay silage," and not "green silage," since the forage is allowed to dry on the field to the 40% water content stage before ensiling, a change which is rapidly accomplished in the dry, hot climate of the South. The best length of silage is 5 cm., the height of the silo 12-18 m., the width 4-5 m., and the weight on cover 6-10 Q. per square meter.

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THE GENUS *LESPEDEZA* IN AGRICULTURE

BY

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The genus *Lespedeza*, comprising 124 species, has the unique distinction of being practically confined in its natural distribution to Eastern North America and Eastern Asia. One species has been reported from Australia and 19 from the highlands of Asia. Of the recorded species, 17 are native to the Eastern United States as far west as eastern Texas, none being found in the Western Great Plains region or west of that area, and 88 species are native to Japan, Korea and China, with three recorded from Java. The genus *Lespedeza* is notable also as being of agricultural importance only in the United States, and the further interesting fact may be recorded that the species important in the United States are immigrants from the Orient, not one of the *lespedezas* native to the United States being useful as herbage plants.

Two species of *Lespedeza* are annuals, *L. striata*, Hook. and Arn., and *L. stipulacea*, Maxim., the others all being perennials. The agricultural value of the genus at

present is represented by these two annual species.

The earliest record of finding *L. striata*, or Japan clover as it is often called, in the United States is 1846, when a specimen was sent from north-east Georgia to the Gray Herbarium. No one knows how it was introduced, but it is supposed to have come with packing in tea shipments. There is no record of the rapidity of its spread in succeeding years, but soon after the Civil War it was found to be quite generally distributed throughout the Cotton Belt.

Its movement north has been slower, but it has now become naturalized as far as near the 40th parallel N. latitude, although it is found in only scattered localities in the Northern limits of its range.

The *lespedezas* appear to require a day of intermediate length for their best development. In an unpublished experiment by Garner and Allard of the Bureau of Plant Industry, it was found that at a constant day length of 8, 10 and 12 hours from June

18th to September 2nd, Korean lespedeza made only 2 to 3 inches of growth, but seeded well and early and died. The controls with a day length of nearly fifteen hours in late June to a little more than twelve in early September made a good growth, and blossomed late while still green and vigorous on September 18th.

On the other hand, under a constant "long day," plants of Korean lespedeza continued vegetative growth, but did not bloom. This fact limits their northern distribution and is of importance in agriculture, since to a great degree the value of these plants depends on their ability to re-seed, and thus to become permanent components of the herbage. In the United States, the present northern limit of *L. striata* is between 39 and 40° N. latitude. The southern limit cannot be stated, as it thrives on suitable soils to the extreme southern part of the United States and records from tropical regions are not available.

Lespedeza stipulacea, known as Korean lespedeza, was introduced from Korea in 1919 and is a larger and earlier form than *L. striata*. It produces seed farther north than *L. striata*, but is not so suitable south of latitude 35° N., since it matures too early and is subject to disease, especially *Sclerotium Rolfsii*, which appears seldom or never to attack *L. striata*. One variety of *L. stipulacea* secured near Harbin has matured seed at Middlebury, Vermont, in latitude 44° N. It is a rather dwarf variety and its value to the agriculture of New England has not yet been established.

Besides the "common" lespedeza (*L. striata*) there are two recognised varieties, Tennessee 76, selected by the Tennessee Agricultural Experiment Station in 1913, and the Kobe secured near the city of that name by an agricultural explorer of the U.S. Department of Agriculture in 1919. Tennessee 76 is characterized by a more erect habit of growth and greater yields than the common, and the Kobe is characterized by greater yields, larger and broader leaflets and larger and distinctive seed. Some selection work with early strains of Kobe and late strains of Korean is under way in the United States Department of Agriculture.

The most active interest, especially in the improved varieties of lespedeza, has of late

years centred in an area between N. latitudes 35° and 40° and from the Atlantic to eastern Kansas and Oklahoma. It is to this region that the Korean appears especially adapted. Some idea of the rapidity with which this variety has spread in the area to which it is especially suited may be gained from the fact that while in 1922 the U. S. Department of Agriculture harvested 240 pounds of seed, about eight and one-half million pounds were marketed out of the crop of 1931. Besides this quantity large amounts of seed were retained by growers for their own use. The spread of this species in Kentucky and its value there have been described in Kentucky Agricultural Experiment Station Bulletin 258, 1932.

These annual lespedezas are all used in the United States as herbage plants mainly for grazing but also for hay; their beneficial effect in soil improvement has been demonstrated. The lespedezas occupy on the worn, usually acid, soils of the southern United States the same general field of usefulness as that occupied by the clovers and alfalfa in the North or in more favoured localities in the South. They do not equal red clover or alfalfa in yields where these flourish, but are used advantageously on soils on which these standard legumes cannot be grown economically. In quality as determined by chemical composition the lespedezas fall somewhat below good alfalfa and red clover but in spite of this fact they are of the greatest importance to southern agriculture and have redeemed literally thousands of acres of worn-out land. After a few years in lespedeza, land that was so worn that it produced but a scanty crop of maize has been brought back to produce 35 to 50 bushels per acre.

These lespedezas are not dry-land plants, though the Korean has survived droughts fatal to red clover. Their growth bears a close relation to moisture. On low, moist, fertile land even if too acid for clover, two to four tons of hay may be harvested; but on upland, especially when dry, the growth remains too short for cutting and is useful only for grazing. A good stand of lespedeza only six inches high has, however, been known to yield a ton of hay to the acre.

A few scattered trials with this crop

have been made in other countries, but no records are available. There would, however, seem to be no reason why between similar latitudes in the Southern Hemisphere these crops should not thrive as well as in the Northern Hemisphere. Certainly their value to the agriculture of the Southern United States cannot be over-estimated.

Very few definite agronomic experiments have been carried out with lespedezas. The selection of improved varieties in Tennessee was described in Bulletin 123 of the Tennessee Agricultural Experiment Station. From this work emerged Tennessee 76, a variety now extensively used. In the same bulletin the Tennessee Agricultural Experiment Station reported on some results with the use of lime and fertilizers. In these trials, lime increased the yields of hay, but commercial fertilizers did not increase yields to any appreciable extent.

At the Missouri Agricultural Experiment Station, on a soil requiring two and a half to three tons of ground limestone per acre to neutralize, the application of lime and of sodium nitrate depressed yields of Korean lespedeza slightly while complete fertilizer and superphosphate slightly increased yields (Bulletin 289).

In some still incomplete experiments by the United States Department of Agriculture upon a soil type differing from that in the Tennessee work referred to, lime showed no effect on growth or yields of Korean lespedeza. It is clear from farmers' experience that results with lime and fertilizers will depend upon local soil and especially upon moisture conditions. All lespedezas thrive in soil of pH5 and above, but below that lime is beneficial.

Grazing trials have been conducted by the Missouri Agricultural Experiment Station with Korean lespedeza and reported in Bulletin 289. It was shown that in 1928 three two-year-old heifers grazing on an area less than an acre in size gained 240 pounds over a period of 122 cattle days.

In another trial 12 yearling heifers grazed for seven weeks, July 1st to September 2nd, on 10 acres of Korean lespedeza, and gained 706 pounds or a daily average of 1.2 pounds for the period.

In connection with the first-mentioned trials, analyses were made of alfalfa, sweet

clover and Korean lespedeza, all on adjoining plots, but the alfalfa and sweet clover plots were limed, the lespedeza plots were not limed. While the nitrogen content was about 0.5 lower in lespedeza than in alfalfa, it is noteworthy that in phosphorus and calcium content the analyses of these two crops were almost identical and the lespedeza on unlimed land made a better showing than sweet clover on limed land.

Korean lespedeza is advised in the area to which it is especially suited as an ingredient of a pasture mixture with Kentucky bluegrass (*Poa pratensis*). When this grass makes a dense sod the lespedeza disappears, but for the first two or three years it makes a valuable part of the herbage. Common lespedeza (*L. striata*) is an ingredient of most permanent pastures in the South.

The lespedezas are inoculated by the same strain of *Bacillus radicolica* as that on the cowpea [*Vigna* sp.]. Observations on very poor soils have indicated that on such soils, the Korean lespedeza is not so readily inoculated as the common, but preliminary results of experiments on better soils have not warranted the conclusion that a special strain of the inoculating organism is involved. Further work needs to be done, but it may be said that where any lespedeza is to be tried on land not previously in cowpeas or in some other plant belonging to the same inoculation group, artificial inoculation should be provided.

During the past year there has been a great deal of interest in the United States in a perennial lespedeza, *L. sericea* Benth., introduced from Japan by the United States Department of Agriculture in 1921. While definite evidence of its value is still lacking, its growth on soils too worn to support a good growth of even common lespedeza has been so striking as to arouse great interest and enthusiasm. It has been determined that good hay may be made from it and that it can be grazed; it would appear to be especially palatable to sheep. When once established it is very resistant to drought and the seedlings endure weed shading better than the clovers. The original plantings on the U.S. Department of Agriculture farm are now ten years old and the plants appear as vigorous as during their second year. Much is still to be learned about the

range and utilization of this plant, but at present it gives promise of being a valuable addition to the herbage plants of the southern United States.

Experiments are under way covering the best methods of securing a stand, yield and quality of hay and value for grazing. These experiments are being conducted near Washington, D.C., at Knoxville, Tenn., and at other points in the South.

During the past summer a survey of the place of the annual lespedezas in the farm system of the upper South was undertaken by the Division of Farm Management of the Bureau of Agricultural Economics in co-operation with the Division of Forage Crops and Diseases of the Bureau of Plant Industry. In this survey, the States of Virginia, North Carolina, Kentucky, Tennessee and Missouri were visited and a study made of the use to which these lespedezas are being put by the farmers. A report on this study will appear in due time.

In Japan and Korea the wild growing lespedezas are sometimes harvested for forage but they are not seeded, only the wild plants being utilized to an unknown extent where

and as they may occur. Some investigations have been made by the Imperial Forest Experiment Station in Japan and by the Government General Forestry Experimental Station in Chosen (Korea). This work has been with the shrubby lespedezas, chiefly *L. bicolor* or its varieties.

Unfortunately, detailed reports on this work are not available at this writing. Attention may, however, be called to a paper written many years ago by O. Kellner, T. Yoshii and M. Nagaoka, entitled "Experiments on the Cultivation of *Lespedeza bicolor*, Turcz (Hagi) as a Forage Crop." Imperial University, College of Agriculture Bulletin, No. 9, 1891. The yields of hay were taken over several years, three cuttings per year being made; the percentage of protein and of other food constituents was determined and a digestion experiment was carried through with sheep.

The digestibility of the hay was found to be lower than that of alfalfa, but the authors say: "The low digestibility of hagi hay is compensated by its richness, so that from a practical point of view its nutritive value is equal to that of medium good lucerne hay"

GRASS SEED PRODUCTION AND GALL MIDGES.

BY

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In view of the increased interest in grass seed production it is important to realise some of the dangers which may beset the industry. A very real menace is the family of Diptera or true flies known as Cecidomyiidae or gall midges.

This group of small flies is world wide in distribution and many of the numerous species are well known as serious pests of such diverse crops as wheat, red clover, basket willows, grafted roses and fruit trees, cactus fruit, violets, chrysanthemums, tomato, cranberry, turnip, rape and hops, only to mention a few. Other members of the family are beneficial, feeding on aphids, coccids, red spider, thrips and rusts. With such diverse habits it is not surprising to find that the grasses are also subject to attack.

One of the best known species, *Dasyneura alopecuri* (Reuter) which attacks meadow foxtail (*Alopecurus pratensis*), was described in 1895, although its grubs and their damage were known as far back as 1860. Another midge doing similar damage on the same grass is *Stenodiplosis geniculati* Reuter, also described in 1895. In spite, however, of these two midges being known to cause serious damage even to the extent of causing the use of the grass in England to diminish in favour of timothy (*Phleum pratense*), recent work (1, 2) showed that there was yet a third species, *Contarinia merceri* Barnes, whose grubs do even more damage than either of the other two. The presumed reason for this lack of knowledge is the fact that the grubs remain in the grass

heads only a comparatively short period and never appear in seed samples. While the grubs of *D. alopecuri* and *S. geniculati* feed on the developing seed and pupate in the seed case and so are liable to be seen by seed testers, those of *C. merceri* prevent seed formation and pupate in the soil leaving only "blindness" or empty husks as an indication of their previous presence.

Two workers, Barnes (3) and Tomaszewski (8), have collected together the literature on the subject of gall midges preventing seed production, and a rather startling state of affairs has been revealed. Such grasses as timothy (*Phleum pratense*), common bent grass (*Agrostis vulgaris*), cocksfoot (*Dactylis glomerata*), smooth-stalked meadow grass (*Poa pratensis*), *Poa trivialis*, *Phalaris arundinacea*, and *Festuca rubra* var. *arenaria*, all have midges preventing seed formation. Only very little is yet known about the bionomics of these pests. Von Oettingen (6) stated that normally 60-75% of the grass seed at Randowbruchs was lost, and in several years 90%. Tomaszewski states the loss in 1930 was 75-80% of the crop. Metcalfe (4), a recent worker at the Rothamsted Experimental Station, has investigated the midges attacking the flower heads of cocksfoot and perennial ryegrass (*Lolium perenne*). Miss Metcalfe's paper is shortly to be published in the *Annals of Applied Biology*. Her results show that two species, one of which was new to science, prevent seed formation in cocksfoot and one species also hitherto undescribed does similar damage to perennial ryegrass. She also shows that the midges are specific in their attack, confining their attention to definite grass species and not living on a variety of grasses. This is important and seems to be a general rule. In fact, very few species of grass gall midges have been definitely proved to have several host plants and one of these is the wheat blossom midge, *Contarinia tritici*, which is known to attack rye, timothy and couch grass, in addition to wheat.

Our knowledge of the subject may be summarised as follows:—

(1) There are many gall midges preventing seed formation in a wide selection of important grasses and the damage done is sometimes very considerable.

(2) Some of the gall midges, e.g., *Dasy-*

neura spp., appear in seed samples as fully grown grubs, while the majority, e.g., all the *Contarinia* spp., do not, leaving only empty husks. The latter are the more dangerous.

(3) Cultural methods of control seem to be the best means of reducing the pest when once it is present. Such methods include (a) the grazing or clipping of the grass to delay flowering until after the crest of emergence of the midges and so the prevention of oviposition (1, 2) and (b) very early cutting to stop the development of the young grubs (8).

(4) The use of clean seed is most desirable. Rostrup (7) advocates (a) dry heating for 35 minutes to a temperature of 59°-60°C., and (b) treatment with carbon bisulphide (1gm. CS₂ to a litre air) in a sealed room for 9 hours. She also recommended keeping the seed over for a year, but this will not ensure the death of all the grubs.

It will be seen from this brief review of the subject that when considering setting up grass seed production in new areas or countries, it is of the utmost importance to know what midges already exist on the grasses previously in the country and to use clean seed. There is a real risk of introducing some of the midges, e.g., *D. alopecuri* has been introduced into New Zealand where Miller (5) reported it as a serious pest. On the other hand, it is unlikely that any *Contarinia* species would be introduced with seed for the reason mentioned previously. However, grasses are so cosmopolitan in their distribution that some potential midge pest may be easily living quietly on wild grasses, awaiting only the setting up of large areas of some particular grass before becoming a pest of first magnitude.

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THEORETICAL AND PRACTICAL SIGNIFICANCE OF LYSENKO'S RESEARCH ON THE VERNALISATION OF AGRICULTURAL PLANTS.

BY

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Work on the vernalisation of agricultural plants, which is as yet little known to research workers of Western Europe and America, has already become available in the Soviet Union to the wide circles of Kolkhoz and Sovkhoz workers, agronomists and research workers as a new and highly effective agromonomical method; as a kind of specific scientific "device" in the theory and practice of plant breeding, and as a part of biological science. The method of vernalisation has been widely used as a means of shortening the vegetative period of a plant by Sovkhoz and Kolkhoz farmers and agronomists directly in the conditions of agricultural industry and by scientific workers, e.g., plant breeders, physiologists, phytopathologists, etc., in research work.

Even at the very beginning of Dr. Lyssenko's work on vernalisation, the author pointed out the fact that the investigation in question was essentially a study of the regulation of the vegetative period of a plant. That is to say, it raises the entire question of the very important and actually fundamental laws of plant ontogeny, or, in Dr. Lyssenko's own words, "the development of a plant from seed to seed."

At the present time certain plant physiologists, especially in Western Europe and America, claim that the discovery made by Dr. Lyssenko on the control of the vegetative period (known at present as "yarovisation")* does not, by its essence and form,

bring anything new to the study of the plant organism. This, however, is incorrect both from the theoretical and practical point of view. Although the inquiries of many physiologists concerning an "arbitrary" change of plant form under the influence of external conditions have much in common with the research on vernalisation, nevertheless they differ essentially from the latter.

The widely known and very valuable investigations by Klebs and Gasner, and the work on photoperiodism by Lubimenko, Maximov, and by many other workers are either very far from the theory and practice of vernalisation or else are by no means identical.

The writer thinks that the identification of such investigations with those on vernalisations interferes greatly both with the correct understanding of the theoretical basis of vernalisation and the practical utilisation of this method, especially in plant breeding work.

Being restricted to the limits of an essay, the present writer is unable to discuss this question in such details as it deserves; he wishes, however, to touch upon at least the most essential points.

The fundamental and indeed decisive aspect which distinguishes the work on vernalisation from other morphological and physiological investigations is the methodological aspect, which is derived both from the personal faculties of a worker and from

* The Latinised form "vernalisation" has been adopted as the English equivalent.

those specific conditions under which he works. Scientific work in our country, the country of Soviets, has been put on a new road, namely, reconstruction on the basis of new methods uniting theory with practice and planning in all fields, more especially the field of rapprochement between scientific institutions and the masses which are building up a new industry. This aspect has played and doubtless is still playing an important role in the methodology of scientific knowledge generally and in Dr. Lyssenko's research particularly. It suffices to say that in 1932 in the Union, the trials on vernalisation were carried out on a scale which has no parallel elsewhere, viz., 45,000 ha. were under vernalised sowings. In 1933 this area will be extended up to 200,000 ha. and at the same time the range of crops to be tested will also be enlarged.

Large financial subsidies, and increased public support together with other facts extremely favourable to the progress of Science are created on the territory of the Soviet Union by the entire system derived from the nature of the Soviet Union itself.

All these conditions make possible the extensive development of the work on vernalisation and at the present time the approaching other aspects of ontogeny relating to the growth and development of plant organisms.

* * *

From the basic statements of the theory of vernalisation, a knowledge of which may be gained from Dr. Lyssenko's original papers*, we can learn that the discoverer takes a plant throughout its entire ontogenetic development (from seed to seed) and distinguishes two aspects which play an important part in the theory and practice of vernalisation, viz., growth and development; without dividing them metaphysically, he distinguishes them as non-identical.

Another theoretical statement of primary importance evolved by Dr. Lyssenko (now the originator of a new line of investigation in biology, i.e., the physiology of plant development), is that the development of a plant consists of successive stages which, although they may not always be manifested morphologically, are in general qualitatively

different and particularly in their demands from the environmental conditions. Vernalisation, in fact, is one of those stages of development of a plant in its ontogeny; it is a stage without the completion of which reproduction of a plant organism is impossible. In the author's opinion this is one of the principal stages in the ontogeny of a plant organism; hence the discovery of this is of enormous importance for the progress of the world's science.

It follows from Dr. Lyssenko's work that an influence on the progress of the stage of vernalisation can be effected by subjecting germinating seeds to an appropriate complex of external factors varying for the different species and varieties (biotypes) of the same crop. This point, which is decisive for the application of the method of vernalisation on a large scale in practice, can also be deduced from the theoretical premises of the founder of vernalisation, viz. from the statement of the classics of dialectic materialism that shoots are already qualitatively different from seeds, that they are essentially plants which can be influenced by appropriate external conditions, thus inducing some changes or other. These changes, although possibly invisible macroscopically, are definite as far as their influence on the progress of subsequent stages and, finally, on the vegetative period is concerned. This for most cereals is of fundamental importance under semi-arid conditions in that it ensures a normal or increased yield.

A correct theory stands in a close relation with human tactics; this fact emerges very distinctly in Dr. Lyssenko's work, whereas it did not appear at all, or only imperfectly, in the work of other investigators on the so-called photo-periodism and some other phenomena. Certain physiologists have claimed that an antagonism exists between the growth and development of a plant, i.e., between its "generative and vegetative" state, and on the basis of this conception they arrived at "the hypothesis of antagonism." This was disproved by the experiments of Dr. Lyssenko; we may find numerous examples illustrating this in the original papers of the "Bulletin Yarovizatzii."

Now, the present writer wishes to note

* See Bulletin No. 9 from the Imp. Bur. Pl. Gen.: Herbage Plants, March 1933.

another point which is also an important achievement in the physiology of development.

By direct experiments based upon a correct theoretical foundation, without the razor or microscope, without biochemical or chemical analyses, the author of vernalisation has found that the qualitative changes which occur during vernalisation, whether natural or artificial, are changes in the growing point. These changes do not penetrate directly into neighbouring or even adjacent cells. All the newly formed parts of a plant which proceed from unaltered (unvernalised) cells remain unaltered; and if, say, new stems are formed (tillering), they will not come into ear until the second and, consequently, all the required stages of the individual development of plant organism, are passed.

On the other hand, it becomes evident that the behaviour of all cells of a plant which are derived from those altered by vernalisation (and, consequently by the onset of other stages) is qualitatively different. Tissues and parts and organs of a plant formed from those cells will be already "more adult" in the ontogenetic sense, i.e., they will be differentiated. When dealing with plants reproducing sexually, then the time of seed formation and maturity will be correspondingly accelerated. The acceleration, however, will not be the result of any stimulation or any factors accelerating growth, but of an appropriate differentiation of tissues. Hence it is quite incorrect to state, as do some physiologists, that the practical aspect of controlling the stage of development consists in a "simple" acceleration of growth and development of a plant as affected (or induced) by the influence of external conditions.

This process is, in fact, much more complicated and has nothing in common with any stimulation, for it is the result of ontogenetic development, of an interaction between plant organism and definite specific conditions without which the usual cycle of development of a plant organism from seed to seed is impossible.

To interpret vernalisation and the "artificial" influence on the progress of plant development in general as stimula-

tion is, at any rate, an undue simplification. In such a case those stages which were passed through by the shoots are not taken into account at all, and the essence of the definition of the stages of development as qualitative changes in cells and tissues during the ontogeny of a plant organism is altogether obscured.

All these conceptions are based upon innumerable actual data obtained both in the laboratory and in the field. From these data, it follows without any doubt that the tissues of the different parts of a plant are not equally ready for further development and, consequently, for organ formation. Thus, the different stages of differentiation in various parts of a plant were demonstrated in soybean and cotton. The results of these investigations permit, in the case of many plants with vegetative reproduction, the utilisation of the phenomena of permanent modification* under field conditions. Suppose that we are able (at present we no longer doubt it) to obtain tubers of potato in those parts of the plant which have already passed through all the stages required for the onset of sexual reproduction. It is known from trials that the potato after flowering (when appropriate conditions of humidity, temperature, etc., are present) begins to form tubers rapidly on its stolons. If all the properties of differentiated tissues which are about to flower be transferred to those tubers which have been induced on cuttings taken from the upper parts of a plant (in flower or about to flower), then in this way we will be able to shorten the period of vegetation (i.e. the time necessary for tuber formation, which is at its height for most varieties during and after flowering) and thus to "convert" late varieties into early ones, at least for several generations, without any direct treatment in commercial growing.

Hence Dr. Lyssenko's discovery begins to penetrate into the domain known as "permanent [or prolonged] modification," which is of primary importance both from the theoretical and practical point of view for plants with vegetative reproduction, since it constitutes a definite "rapprochement" between the developmental morpho-physiology and hereditary structure of the plant organism**.

* Probably the German "Dauer Modifikation."

** Nevertheless the author is far from agreement with the opinion of many investigators that a "permanent modification" is a transition between modification and mutation, as this is a simplification.

The author is firmly of the opinion that a further development of Dr. Lyssenko's work along this line, if closely related with genetic investigations, will lead eventually to more concrete conceptions on the question of origin of characters and explain as yet obscure and formalistic conceptions of the problem of the so-called manifestation of the genotype; thus it will eliminate the gulf that lies between the gene and the character and sometimes introduces a great deal of confusion in the understanding and practical utilisation of the phenomena of heredity and variation. The conceptions hitherto existing rendered necessary a formalistic treatment of all the problems related to these phenomena and have led many Soviet and foreign geneticists to a mechanistic interpretation which, of course, would not supply the conditions necessary for a more rapid advance in this extremely important branch of biological science.

Both the plant breeder and the geneticist have now obtained a certain amount of elucidation on one important and valuable character, viz. the "vegetative period" of a plant.

From data on wheat, it has become quite clear that, from the point of view of the physiology of plant development, the vegetative period under the natural and industrial conditions of a given region depends upon two factors, viz. (i) the degree to which the conditions of a given region do or do not coincide with those required by a given plant to pass through the stages of vernalisation (two stages of development, according to Dr. Lyssenko's terminology); and (ii) the same for the third stage, conventionally known as the light stage or "photo-stage."*

The general principles of the theory of plant ontogeny indicate that every stage of the same plant or of the same variety of a given plant requires for its progress different external factors, while the same stages of different varieties or species also differ from one another in this respect. Hence we are led to conclusions of the greatest importance, both for agronomy and methods of plant breeding. In the latter case, the selection of parental forms to be crossed in order to

obtain an early variety for a given region is particularly important.

In this we perceive also an interpretation of the phenomena of polymery and complementary factors (at least so far as early maturity is concerned) which until recently were interpreted in genetics only from the formal point of view, which was but little help in a deliberate selection of parental forms for breeding earlier types.

Hence, in addition to what is already known from a paper by A. Sapehin (*Züchter*, 1932. Vol. 4. No. 6) concerning the importance of vernalisation for breeding work, we have from later investigations further new theoretical and actual data which allow us to raise the methods of breeding to a higher level, and, in addition, give us larger practical possibilities in the utilisation of initial material for varietal breeding.

It is clear that by crossing definite varieties (the selection of which is to a certain extent determined by Dr. Lyssenko's work) we are able now to obtain in one variety such a combination as will allow all stages of normal development to take place in a shorter period of time under natural conditions and give maximum positive results in agricultural practice.

Such are, in brief, the conclusions of recent work on the new theory arrived at by the investigator in the U.S.S.R.

* * *

We shall now proceed to the second question of this paper, i.e., to the question of the significance of the above-mentioned theory for fodder plants. It is quite clear that the general statements are equally applicable to all plant forms and hence the author has no need to repeat them here.

In this section the writer wishes to throw some light upon the actual data mainly concerning those plants with which the Odessa laboratory is dealing. The instructions for vernalisation of millet, maize, sorghum, and sudan grass were already published in Nos. 2-3 of "*Bull. Yarovizatzii*."

These plants are very valuable fodder crops under the conditions of semi-arid zones of the Union. In addition, sorghum and maize are at the same time industrial plants, for in conjunction with the reconstruc-

* Particulars are given in "*Bull. Yarov.*" No. 4 and in the further discussions of this paper.

tion of the whole system of agricultural industry, i.e., the conversion of private small rural holdings into extended socialistic mechanized industrial centres, the utilisation of these plants for various purposes has opened up large possibilities.

Millet may now be called a classical plant in the study of stages of development in so-called plants of high temperature and "short day." A large body of data concerning this plant may be found with theoretical generalisations and practical conclusions in all numbers of "Bull. Yarov." so far issued. In experiments, Dr. Lyssenko succeeded in proving that, in contradiction to the statements and views of other physiologists, this plant, as well as some others, does not require for its normal development the so-called "photoperiodism," and that experimental data obtained by those physiologists were either misunderstood or incorrectly interpreted.

The progress of stages of development in these plants is also connected with a definite complex of external factors; the latter includes darkness without which,* though other requisite conditions of temperature, humidity, etc., may be present, the progress of stages of development and hence the formation of reproductive organs and fruit formation are impossible. It is not a short day or, even less, the alternation of short and long days (photoperiodism), but a long night that is required by these plants at definite stages of development.

Hence, on the whole, the division into short-day plants and long-day plants is essentially very conventional; this rather prevents a thorough understanding of the progress of plant development, for when a definite stage is completed, such plants develop better under a "continuous" day (artificial illumination) and accumulate more dry substance per unit of time.

Correct theoretical premises concerning these plants make it possible to find the "optimum" conditions for the progress of stages of their development, and by treating material to obtain seed yield in a shorter time. In Bulletin No. 9 on "Vernalisation" are photographs of sorghum and sudan grass which illustrate the possibility of obtaining from treated seeds under field conditions an

earlier coming into ear and hence an earlier seed yield, and more rapid accumulation of vegetative mass (fodder) per unit of time.

All these facts are also very valuable from the practical point of view for "high temperature" plants such as sudan grass, sorghum, and maize; for they allow later sowing not only without prolonging, but on the contrary, with a shortening of the period of time between sowing and the utilisation of products. Late sowing of these crops is of great agronomic importance, as more favourable conditions are thus created for presowing treatment and for the initial stages of growth, which are very sensitive to the temperature of the environment and the purity of the field. In addition, it is very important for after-harvest cultivation of these crops. Shortening the period of time between sowing and crop (by creating appropriate conditions so that the initial stages of development are passed in the germinating seed) in all cases of cultivation of such crops as sorghum and sudan grass (which while being annuals are able to grow up vigorously after mowing) enables us to obtain an "extra" cut and thus to increase the general productivity of these fodder crops. Small trials conducted at this Institute in 1932 with some varieties of sorghum and sudan grass have confirmed the above statements. It is quite possible that in the near future another stage of development of these crops, namely, the stage which the author associates with the onset of rapid growth, will also be made to pass in the germinating seed; then we will be able to raise the utilisation of these crops to a still higher level.

The method of regulating stages of development acquires a special and exceptional importance in the utilisation for green fodder and silage of highly productive varieties of sorghum which either do not ripen or do not even come to ear under the conditions of Ukraine. A number of sorghum varieties are of Indian origin, while some varieties of maize do not find in this country the conditions requisite for the normal progress of all stages of their development. Though these varieties, as has already been mentioned, are highly productive for green fodder, they cannot be used without the

* Not all varieties of sudan grass, maize and sorghum, however, require darkness; in this case varietal differences are especially marked.

treatment of germinating seeds after Dr. Lyssenko's method, because they do not come to seed. By applying this method, the above-mentioned obstacles are removed and thus very valuable varieties of maize and sorghum can be introduced into agricultural practice. In this case one can speak of vernalisation only as a method for seed growing, since the utilisation of these varieties for green fodder is possible even without vernalisation.

Recent investigations have shown that different varieties of maize, sorghum, and sudan grass differ widely from one another in their demand of external factors required for normal development; that many of them can develop freely under a continuous day, while others in this country require necessarily darkness, together with appropriate conditions of humidity and temperature. For plant breeding, for morphogenesis in breeding, the above-mentioned methods take a place of primary importance, as they permit the crossing of varieties which it is usually impossible to cross in this country. For the elaboration and application in practice of methods of accelerated breeding, when it is desired to obtain several generations in a year, the method of regulating the stages of development is especially valuable, because by its aid it is possible to produce such a number of generations (in all varieties) as cannot be obtained under greenhouse conditions. A special reference should be made to the care of such plants as wheat, lucerne, potato, clover, etc.

Our country, which is vigorously carrying out reconstruction in all domains of life, extends the same demands to scientific institutions. This applies equally to genetic work, which has recently been reconstructed along the lines of evolving new "methodique" which will answer better the

needs of rapidly-growing industrialisation. We are all collaborators in the construction of "breeding factories," the creation of which is partly based upon new discoveries in developmental physiology.

For perennial and biennial fodder crops (e.g., sainfoin, clover, beet, lucerne, etc.), Dr. Lyssenko's method is also valuable, as by its aid the vegetative period of these plants can likewise be shortened and the seed production and accumulation of dry mass regulated.

The limits of a journal article do not permit my touching upon all the questions, both theoretical and practical, which are already solved or set by this new branch of biological science, i.e., developmental physiology. To us, plant breeders and geneticists of the Union, and more especially those working at the Institute in direct collaboration with Dr. Lyssenko, it is clearly evident that a new page has been opened in science, which shows the way towards true control of morphogenesis of plant organisms during ontogeny. This theory enables one to raise such questions as the introduction of Egyptian cottons into cultivation under the conditions of Ukraine; the crossing of sorghum with sugar-cane under the conditions of this country*; while it has already made possible a much wider utilization of the world's resources of certain agricultural crops. Finally, the writer is firmly of opinion that in the nearest future, by the mutual endeavour of Soviet and foreign scientists, great achievements may be expected in the study of the relationship between ontogenetic and physiological development of plant organisms, and in this Dr. Lyssenko's theory will occupy a notable place.

Jan. 25, 1933.
Leningrad.

* The author stresses "under the conditions of this country," since the honour of the discovery of this being possible belongs to an Indian scientist.

CONFERENCE

CONFERENCE ON AGROSTOLOGICAL PROBLEMS AT ADELAIDE.

A Conference was held at Adelaide, South Australia, on October 13th and 14th, 1932, when the following persons were present: Professor A. J. Perkins, Director of Agriculture, S.A. (Chair); Mr. W. Davies, (Welsh Plant Breeding Station, Aberystwyth); Drs. B. T. Dickson and A. McTaggart (Council for Scientific and Industrial Research, Canberra); Messrs. R. H. Bevin (Department of Agriculture, Tasmania); H. A. Mullett (Department of Agriculture, Victoria); J. N. Whittet (Department of Agriculture, New South Wales); Dr. A. R. Callaghan (Principal, Roseworthy Agricultural College); Professor J. A. Prescott, Dr. J. Griffiths Davies, Messrs. H. C. Trumble and A. B. Cashmore (Waite Agricultural Research Institute); Messrs. R. C. Scott, Rowland Hill, S. B. Opie and A. L. Warren (Department of Agriculture, South Australia). The Hon. Minister of Agriculture, South Australia, gave a short opening address and Professor Perkins was appointed Chairman.

The Chairman then referred to a special resolution agreed to by the Standing Committee on Agriculture in January, 1932, to the effect "that the Standing Committee on Agriculture recommends that the technical officers of the various State Departments of Agriculture and other institutions engaged in pasture improvement be brought together with a view to discussing—(1) pasture work in each particular State, and (2) the possibility of developing as far as possible a uniform technique throughout the Commonwealth, and also that Mr. Davies be invited to attend after the completion of his present tour of Australia, and after his report on that tour has been circulated." The report was not completed, however, at the time of the Conference, but Mr. W. Davies, Empire Grassland Investigator, was present to meet

personally those interested in pasture work in each State and to give them his impressions. After Dr. Dickson had expressed the regret of the Departments of Agriculture of Queensland and Western Australia that they were unable to be represented at the Conference, Mr. Davies read a paper of which the following represents a slightly abridged rendering.

* * *

With your permission, I would like to outline briefly my impressions—and the reaction to those impressions—formulated in Australia during the past year. Concerning the grasslands of the Commonwealth, I think the first impression that must strike anyone interested in them is the extensive area which they occupy. We are told, furthermore, that in monetary value some 60 per cent. of Australia's total exports are derived directly from her grasslands. These grassland production figures include dairy produce, wool, beef, mutton, lamb, hides, skins and so on. Having regard to the extensive area and importance of grassland in Australia we must realise that any scheme of grassland improvement having as its objective the more economic production of a greater quantity of food from a given area, must have fundamental significance and must reflect upon the well-being of the community as a whole.

Let us briefly consider some aspects of organisation relating to pasture investigations and their relation to practice. We must lay emphasis on the fact that we are dealing with a subject which in its present form is relatively new, and the implications of which have not yet filtered into the mind of the lay community.

Speaking as a research worker one feels that the findings of research should not be passed directly into practice. Rather

should they be handed over to qualified advisory departments whose officers are in intimate contact with current practices in various localities. These field advisory officers could demonstrate and test new practices—the outcome of research—which, if found useful under local conditions, would be recommended to the practical man—at first to the more progressive, no doubt. If endorsed and found acceptable these findings would pass ultimately into general farming practice. The research unit, advisory unit, progressive farmer and farming community in general, may therefore be looked upon as links in a chain. The closer those links are welded together the more economically profitable is the work of each one likely to be to the nation at large.

Pasture studies may be viewed along four major avenues of thought, namely those of (a) species, (b) strain, (c) soil fertility, and (d) pasture management. A factorial summary of this type can be of considerable assistance in visualising in proper perspective the problems which concern pasture improvement. We can deal briefly with these four factors.

(a) *Species*. Considering the problem of species on Australian grasslands one is continually asking the question whether annuals or perennials are of the greatest value as pasture plants. In many districts annuals have played an important part, but perennials have, I believe, a more fundamental bearing upon the problems of pasture improvement in Australia. That the habitat allows of the growth of perennial pasture plants is evident from the fact that over large areas now dominated by exotic annuals the original herbaceous vegetation was marked by an abundance if not a dominance of perennial grasses including members of the genera *Danthonia*, *Stipa*, *Agropyron*, *Themeda* and *Microlaena*. The mainstay on the swards of out-back sheep and cattle stations at the present time, moreover, is not the annual, but the perennial, the salt bush, blue bush, native perennial grasses and the perennial fodder trees. True the ephemeral annual vegetation is a welcome addition to the grazings after periods of rain, but one surmises, however, that its greatest value is to provide the perennial with a period of rest during which

the latter may make adequate vegetative recovery.

On those areas which are now dominated by exotic annuals and which therefore have a relatively short period of usefulness each year, the question arises whether a new set of perennial species can be substituted in place of the existing annual sward. It is important to know also whether a suitable legume can be incorporated into those pastures. The grass-clover sward is usually more valuable as a pasture than is its non-leguminous equivalent.

(b) *Strain*. When the species likely to be useful under a given set of conditions are known, their further study must have regard to strain. There is abundant evidence throughout Australia to show that strain in pasture plants does matter. It is obvious, for example, that a great deal can be gained by the investigations of strain in subterranean clover, some of the early flowering forms having distinct advantages under low rainfall conditions. Nearer the coast and in the belts of higher rainfall the "early" forms of subterranean clover are of lesser value than the "late" and "mid-season" strains. In the same way, strain in perennial ryegrass is important throughout Australia. It is common knowledge that the commercial strains of this grass are inclined to behave like annuals. Perennial ryegrass as sold on world markets to-day is not a suitable pasture plant. There are at least three regional strains of perennial ryegrass which are superior as pasture plants compared with the commercial variety. I refer to the English Old Pasture type, the Hawke's Bay type from New Zealand, and that from Colac and the Western Districts of Victoria. It is also possible that superior types may be found on the old pastures of New South Wales and Tasmania.

A further point I would like to emphasise is that whereas soil and climate may have had considerable influence on the development of contrasting strains, the biotic influence, i.e., the influence of man, and his animals, has been the most important factor in their development. We can thus explain the differences found in English Old Pasture when compared with Hawke's Bay and (or) Colac ryegrass, in terms of pre-management of the pastures from which

these regional strains are produced. These strains show differences inasmuch as they are a reflex of the type of grazing management of the past.

I might refer to the advantages of seed certification in connection with herbage plants and point out that there is need to set up machinery whereby seed of approved strains is easily recognised. There are a number of areas in Australia which might well grow seeds of ryegrass, *Danthonia*, cocksfoot, clovers, lucerne and other pasture plants which are in common use in the Commonwealth. Where a new industry such as, for example, herbage seed growing is being developed in new districts, certification provides a guide to the grower as well as a guarantee of quality to the trade and consumer.

Touching on the research aspect of strain in herbage plants, regional strains can be improved by mass selection and the material thus accumulated can be used for studies of a genetical nature with a view ultimately to breeding pedigree lines. Just as mass selection follows upon the ear-marking of regional strains, so bred material comes as a subsequent development of mass selection.

(c) *Soil condition or fertility.* Pasture plants demand certain standards of soil fertility and to obtain the maximum benefits from them we must provide the standards conducive to their development. The soils of Australia are usually deficient in phosphates, and the response of pasture legumes to dressings of phosphate is a well-known phenomenon. The value of legumes for building up soil condition is widely recognised. The growing of clovers to enhance soil fertility is a common practice in many parts of the world, and no less so in regard to subterranean clover in temperate Australia. The great thing subterranean clover is doing is building up soil condition, so that that soil condition will be made conducive to the growth of high fertility demanding grasses. The same thesis can be propounded for lupins in the sandy soils of Western Australia and for white clover in Great Britain or in New Zealand. One of the greatest forward movements in connection with pastures in Queensland is likely to be connected with the finding of a legume to do in that State

what subterranean clover has done for South Australia, and is likewise doing in other parts of temperate Australia.

On areas seeded down to subterranean clover there is evidence which indicates that after some years of dominance of the clover a gradual sward change sets in. Exotic annual grasses tend to increase year by year and may ultimately attain dominance. The robust growth of these annuals (*Festuca* spp., *Hordeum* spp. and *Bromus* spp. chiefly) in such a sward type would appear to indicate that the soil condition is such as would maintain the requisite high-fertility-demanding grasses. It may therefore be that the period of maximum dominance of subterranean clover is the time when perennial ryegrass, *Phalaris tuberosa* and similar perennial grasses might successfully be incorporated into these pastures.

The use of subterranean clover as a pre-crop is sound practice on land whose initial fertility is low and where introduced perennial grasses are ultimately desired as major elements of the pasture. Subterranean clover is valuable therefore not only for the amount of feed it produces but also for the part it plays in building up soil condition.

(d) *Pasture management.* Time will not allow me to deal fully with the various aspects of grassland management. We have for example to determine the place of rotation or systematic grazing. It is obvious that systematic grazing is an essential practice if we are to maintain high quality pastures. In our pasture investigations we have to determine the place of the mower, the harrow and the plough as grassland implements. Mr. Whittet will tell us that on the paspalum pastures of the New South Wales coast, periodic renovation is absolutely indispensable. The conservation of feed reserved for periods of shortage is a major necessity and an essential part of modern grassland farming. It would seem that under drought conditions such as obtain in Australia conservation of fodder reserves becomes as important as in England. The English six months of winter is physiological drought just as is the non-growing rainless period in Australia.

There is one aspect of grassland management which is very important: that is, in connection with the back country grazings,

One would like very much to see experiments much on the lines of the work which the Adelaide University have conducted at Koonamore, dotted about all over Australia and particularly in low rainfall zones. The Koonamore work hits fundamentally at the problems of the back country. The station owner in Australia is not only extremely keen to know more about his pastures, but wants a definite lead in regard to the principles of grassland management. One wonders whether it would be possible on these back blocks to maintain "hospital" paddocks, where in times of stress the stock can be congregated. There is urgent need for researches concerning such queries as the following and having particular regard to low rainfall belts. What is the value of "spell" paddocks? What is the place of conservation of grass and can such be carried out economically? What is the place of growing special crops for conservation? Is subdivision of large paddocks economic and what relation should the size of paddock bear to (a) size of flock, (b) carrying capacity of the pasture?

* * *

In the discussion which followed, Mr. Whittet asked the speaker for any information regarding the origin of the Hawke's Bay strain, and its introduction to New Zealand. This was regarded as the most interesting type of ryegrass yet tested in New South Wales. In reply, Mr. Davies stated that a century ago Britain was producing ryegrass commercially, but it came in the main from threshings—quite often hay loft seed. Up to 1850 it would seem that when buying "Ray" grass, as called then, one was buying something equivalent to the present English Old Pasture. New Zealand imported that article during the middle 19th century. Between 1850 and 1870 the trade in this seed was being organised so that there was probably some change in type. Ryegrass was imported into N.Z. mainly from Britain but some may have come from other European countries as well. Importations were made into both the North and South Islands. In the North Island this ryegrass seed was sown and put under a type of management which was not dissimilar to the management on the English Old Pastures. In other words the pastures were grazed by sheep or by cattle.

These pastures may in the interim have been ploughed, but if so, in most cases they were reseeded with local seed. In the South Island on the other hand the call was for temporary leys and the ryegrass was cropped and taken for seed. Fields were resown and these again put up for seed. This system of management favoured the propagation of the more annual types of ryegrass. Consequently the type developed in the South Island has been found unsuitable as an ingredient in mixtures for permanent pasture. Unfortunately, it is this type of ryegrass which has dominated the New Zealand market in recent years. The Hawke's Bay strain on the contrary is a reasonably good article, and in the present state of world markets is an extremely useful one from the viewpoint of being used in mixtures for permanent pasture.

Other points which were discussed by the members of the Conference included the tendency for annuals to predominate over perennials in much of the pasture land after settlement and top dressing, and also the effect of phosphatic dressings on *Danthonia* pastures.

At the close of this address, the following gave accounts of the pasture work in progress in their particular State—

J. N. Whittet, New South Wales.
H. C. Mullett, Victoria.
R. H. Bevin, Tasmania.
A. McTaggart, Federal Capital Territory.
H. C. Trumble } South Australia
J. G. Davies } (Waite Institute).
R. C. Scott, South Australia, Department of Agriculture.

W. Davies { Western } In the
 { Australia, } absence of
 { Queensland } delegates.

A "Resolutions Committee" was appointed as follows:—J. N. Whittet, H. C. Mullett, B. T. Dickson and W. Davies. The following resolutions were discussed and passed by the Conference.

Resolution 1.—That it be a recommendation from this Conference that investigations be carried out in order to establish standards of true description, germination and purity with respect to agricultural seeds; these standards to be incorporated into the schedules of the

relevant Commonwealth Quarantine and Commerce Acts and to serve as a basis for standards under existing State Seeds Acts.

Resolution 2.—That this Conference affirms the principle that each State should have a Seeds Act which should be as nearly as possible uniform.

Resolution 3.—That in the interests of the development of improved regional strains of agricultural plants, especially of pasture plants, this Conference affirms the desirability of certification of seeds from recognised strains, such certification to be a function of the respective Departments of Agriculture.

[The proposal "That this Conference stress the desirability of prohibiting the sale of *Melilotus indica* throughout Australia" was not carried, but the Conference agreed to Resolution 4.]

Resolution 4.—Opinion of dairy branches of States to be sought.

Resolution 5.—That attention be drawn to the fact that the trade name of *Agrostis tenuis* should be "brown top" and not "creeping bent," as at present used in trade circles.

Resolution 6.—That this Conference of agrostologists directs attention to the fact that 60 per cent. of Australian exports in point of value are derived from pastures, and having reviewed the research investigations and advisory work in pasture improvement in Australia is of the opinion that the significant results already achieved—especially in respect of the adoption of top-dressing, better pasture management methods, and the use of introduced pasture species, as well as improved strains of *Phalaris tuberosa*, ryegrass, cocksfoot, subterranean and white clover—warrant vigorous expansion of the work throughout the Commonwealth.

Resolution 7.—That in view of the fact that Australia imports the bulk of its seed from abroad, Conference is of the opinion that a larger proportion of this seed could be grown within the Commonwealth and urges that consideration be given to the desirability of establishing this industry on a basis of production of high quality regional strains.

Resolution 8.—That Conference is of the opinion that for the successful establishment and maintenance of superior regional strains of pasture plants, the fertility level of extensive areas of Australian soils would have to be raised. The inter-dependence of leguminous seeds and phosphatic top-dressings has been shown to be absolute under our conditions and the extension of current practices in this direction is strongly commended.

Resolution 9.—That Conference is of the opinion that there is an outstanding necessity for the introduction of suitable pasture legumes for sub-tropical and tropical Australia and such is considered to be fundamental to the improvement of these pastures.

Resolution 10.—That Conference recommends that attention be drawn to the necessity for the greater conservation of surplus pasturage in the form of grass silage or hay, which practice can be made to conform to the best methods of pasture management.

Resolution 11.—That consideration be given to the question of semi-arid and arid-pasture areas in which deterioration of pastures has reached serious proportions and Conference strongly recommends special investigations into this question. It is pointed out that a beginning has already been made at Koonamore in South Australia, and it is recommended that work should be extended to other areas.

Resolution 12.—That this Conference moves that the C.S.I.R. ask the Waite Research Institute and Werribee to supply a general statement of the technique followed by them in pasture studies.

Resolution 13.—That the C.S.I.R. ask Professor Prescott to outline a system of sampling for analyses of pasture plants which could be submitted to the various States for their guidance.

Resolution 14.—Prohibition of the sale of imported cocksfoot seed (excluding New Zealand certified seed unless) seed is stained.

Resolution 15.—That the States who grow Sudan grass seed adopt a method of seed certification.

Resolution 16.—That this Conference asks that seedsmen be compelled to attach the common name specified by the regulation.

Resolution 17.—That this Conference recommends to the C.S.I.R. that the Division of Plant Industry proceed with the standardisation of common and botanical names of grasses and clovers—the various Departments of Agriculture to be circularised and general adoption by seedsmen to follow.

Resolution 18.—That in view of the importance of cheap fertilisers and soil amendments to pasture lands, this

Conference recommends that an investigation should be made into the economics of fertiliser costs, with a view to bringing about reduction in costs of raw material, costs of manufacture, and costs of transportation with a view to an all-round reduction of the cost to the user.

The meeting closed with the passing of a vote of thanks to the Chairman, who then thanked Mr. W. Davies for his valuable address. Mr. Davies replied appropriately, expressing his best wishes for the future development of the important pasture work in progress in the Commonwealth.

GRASSLAND RESEARCH

SOUTH AFRICAN GRASSLANDS.

Although there are unquestionable reasons for the necessity of focussing the Union's farming production on the products from animals, and on fruit, these animal products must remain poor in quality and low in quantity while the pastures are so poorly managed as they are at the present day. The situation can certainly be changed by controlled grazing and cultivated pastures. Recognising the advantages of team-work in attempting to hasten progress in solving the country's pasture problems, the University of Pretoria and African Explosives and Industries, Ltd., have joined forces in appointing a Committee of technical men: the P. U.—A. E. and I. Grassland Research Committee, composed of six members.

Pretoria University.

- H. D. Leppan, B.Sc. Agric. (Toronto),
M.Sc. (Cantab.), Professor of
Agricultural Economics.
J. M. Hector, B.Sc., Professor of
Agricultural Botany.
W. R. Thompson, B.Sc. Agric. (S.A.),
Lecturer in Agronomy.

African Explosives & Industries, Ltd.

- Thos. D. Hall, B.A. (Cape), M.Sc. Agric
Cornell), Agricultural Adviser.
A. Lindsay Robb, N.D.A., N.D.D.,
Chief Grassland Officer, Imperial
Chemical Industries, Ltd.
D. Moses, M.Sc. Agric., Agronomist.

* * *

In their first publication (1) the problems and possibilities of the question are reviewed. The first four parts of this work are (I) introductory, (II) topographical and climatic influences, (III) soils and (IV) review of grassland research abroad.

Section V deals with the grassland situation in South Africa. The low production and poor quality of the herbage is almost universally attributed to a low and erratic

rainfall, but it appears to be the inevitable and logical result of consistent neglect and bad management for many years. The excessive overgrazing evident during low-growth periods reacts very unfavourably on the better types of herbage plants such as rooigrass [*Themeda triandra*]. The injury suffered by the superior herbage components and the decline in soil fertility through lack of suitable fertilisers has eliminated these high-fertility demanding species in favour of poorer types. Thousands of acres of potential rooigrass country are now carrying swards in which *Eragrostis* or *Aristida* have become dominant, according to the degree of deterioration of the veld.

The complete restoration of these South African grasslands is not merely a theoretical possibility, but a sound economic and practical proposition, since the problems do not differ materially from those of other countries, but are merely more acute because of the severity of the punishment.

In considering pasture development, two aspects of the problem are immediately apparent—that which relates to the existing veld and, secondly, the potentialities of artificial pastures [Section VI.]. The raising of the soil fertility is one of the primary steps in the repopulation of the soil with productive and palatable plants. Phosphate and nitrogen have been shown to be of fundamental importance to the better grassland species in South Africa, while lime and potash do not appear to be of quite the same importance. Lime should, however, always be supplied with phosphoric oxide. Another step is the introduction of more rational grazing, varying the treatment according as to whether there is or is not a clear demarcation between sweet and sour veld. A proper study of pioneer grasses should be made under different conditions of soils, climate and treatment. The pioneer species found varies in different localities, being sometimes *Urochloa*, *Digitaria* or *Pennisetum*.

In the establishment of new pastures, on which subject little has so far been done, some of the failures recorded may have been due to the sowing of high-fertility demanding species on soils too poor to support them. A thorough exploitation of all possible indigenous and exotic species is necessary under conditions of proper treatment, and the suitable components, for example indigenous clover varieties or English wild white, should be introduced. Among exotic species which may be selected as productive during seasons when the natural veld gives little grazing, usually during winter and early spring, are *Dactylis glomerata*, *Phalaris bulbosa*, *Bromus unioloides*, *B. inermis*, *Holcus mollis* and New Zealand tall fescue [*Festuca* sp.]. *Paspalum dilatatum*, although essentially a summer grass, is of outstanding importance on account of its close, dense turf, productivity and capacity to "blend" well with all the above grasses. Promising grasses from the indigenous genera are *Pennisetum*, *Digitaria*, *Urochloa*, *Panicum* and *Setaria*. For South African conditions, species with creeping habits or spreading roots are to be preferred to the tussock-forming types, as high utilisation of moisture is important.

The results of veld burning on the herbage constituents would appear to vary according to locality. At Cedara, burning while the vegetation was in a dormant condition increased the dominance of rooigrass [*Themeda triandra* var. *Burchellii*], while in the Western Transvaal, burning during May or September was decidedly harmful.

Section VII deals with future prospects, mainly from an economic aspect, while Section VIII contains a survey of local problems, the majority of which are dealt with in Section IX as the aims of future research. The thirteen items requiring investigation are as follows:—

(1) *Explorative work.* To explore all promising regions in and beyond Africa for plants of possible value for this country.

(2) *Species.* It is important to obtain accurate information regarding the behaviour of different species—indigenous and exotic—under varying conditions, when grown alone and in competition with other species. Amongst other considerations are the follow-

ing:—growth form, persistency, productiveness, seasonal growth, ratio of leaf to stem, palatability and seed production.

(3) *Fertilising experiments.* Work on the use of fertilisers on grass is very necessary in order to ascertain herbage plant requirements for zenith production under widely diverse conditions, and effect on palatability and mineral content of sward. It is essential to determine the balance of fertiliser constituents, frequency and time of application, and economic limits for different conditions. The degree of response of different species and grassland types should be studied.

(4) *Grass silage investigation.* A problem of the greatest importance to any grassland country of erratic and unreliable rainfall is the conservation of its surplus herbage. Work is necessary to elucidate such points as time of cutting, stage of growth, methods of ensiling, most suitable temperatures, and effects of adding various materials during the process of ensiling on feeding value, keeping properties and wastage.

(5) *Cultural experiments.* The use of mechanical implements as an aid to increased production should be studied. The reaction of herbage plants to cultural treatment at different seasons and of varying degrees of intensity should be determined.

(6) *Winter cereals as herbage plants.* Further work is necessary to determine how far winter cereals, now fairly extensively grown as temporary winter pastures, can be used to greater advantage with the more promising species of grasses. The addition of a rapidly growing and highly productive plant like Italian ryegrass, for example, might extend the grazing over what is undoubtedly a very critical period.

(7) *Arable land weeds.* Investigations should be carried out to determine how far the "weeds" left over after harvesting cultivated crops could be developed as temporary pastures, especially for winter grazing.

(8) *Grazing research.* A critical study of the plant-animal complex or the influence of the biotic factor is fundamental to high pasture production. It is of vital importance to determine how to graze efficiently without impairing the future productivity of the sward. The reaction of different species and

grassland types to the grazing animal at different stages of the season and under varying climatic influences should be studied.

(9) *Botanical research.* Investigation is very necessary into changes of botanical composition of sward and their significance under different conditions of management, including burning. Genetic studies, selection work and applied plant breeding are other important aspects which would amply repay organised research.

(10) *Strain investigation.* The far-reaching effects of improved strain of herbage plants on production need no emphasis. The genera which suggest themselves for strain investigation in South Africa are *Pennisetum*, *Digitaria*, *Chloris*, *Paspalum*, *Panicum*, *Urochloa*, *Setaria*, *Brachiaria*, *Themeda*, *Echinochloa* and *Hemarthria*. There is also ample scope for work of this nature on several of the less popular genera, such as *Eragrostis* and *Sporobolus*.

(11) *Chemical and biochemical research.* The problems underlying the chemical aspects are numerous and of great importance. Apart from those already outlined under the heading "Fertilising experiments," some of which will also constitute problems for research over a long period, further work is highly desirable on the seasonal protein and mineral composition in addition to the composition as effected by diverse treatment and different systems of management. The chemical changes in grass silage making for semi-tropical conditions affected by periodical drought is of outstanding importance. The proper use of concentrates for cows on highly nutritive grass is of economic importance. The effect of burning on organic matter and soil moisture and the causes underlying change of colour and early growth should be determined. Why is the response to nitrogen greater on grass than on arable land? What is the residual value of fertilisers applied to grass?

(12) *Seasonal herbage production.* The seasonal variations and total herbage production should be determined under the widest possible conditions of soil, climate and sward.

(13) *Total production and percentage utilisation.* The discrepancy between production and utilization of herbage should be measured as an incentive to improved grazing

technique. If the percentage losses through imperfect management and their value were ascertained even approximately, it could not fail to stimulate greater interest and attention in the direction of higher standards of management.

The bibliography to this publication contains 245 references.

* * *

Abstracts of several recent papers written by the members of the P. U. — A. E. & I. Grassland Committee are now given.

ROWLAND, J. W., and HECTOR J. M. (2).

The grazing conditions on the farm Swerwerskraal, district Potgietersrust, were analysed. There are seven camps on the farm, on which ten communities may be recognised. It was shown that the cattle follow a grazing cycle which has induced a definite succession in each camp. Starting from the drinking places, the communities occur in regular successive zones, the area occupied by each zone varying from year to year and with the intensity of the grazing. In each camp, however, the zones can be recognised. It is believed that the deterioration resulting could be checked and the conditions improved by:—(a) increasing the fertility or (b) some system of camp resting.

The probable consequences of resting a camp (a) throughout the growing season; (b) throughout the first half of the growing season; (c) throughout the second half of the growing season were analysed. It was concluded that resting during the latter part of the growing season, when the rains are more reliable, would be the most beneficial.

As a consequence, the proposal is (tentatively) advanced that an "intensive late summer grazing system" would best meet the requirements of the farmer, the veld and the livestock under the conditions here outlined. Further investigation will demand a reconsideration and possible modification of the proposals advanced.

HALL, Thomas D. (3).

With a view to ascertaining to what extent the intensive system of rotational grazing on well fertilised grass could be applied to veld conditions, a number of experiments were started late in the season of 1929-30 and also in 1930-31. The ex-

periments were planned to run for five years, and to answer if possible the following questions:—

(1) What is the carrying capacity of veld under a system of rotational grazing in small camps?

(2) What effect do various fertilisers have on the carrying capacity?

(3) What is the effect of these treatments on the botanical composition?

(4) Do animals show a preference for one or other treatments?

(5) Is the veld better grazed under certain treatments, that is, is there less selective grazing?

(6) Does the use of fertilisers affect the drought resistance of the veld and its recuperative properties?

(7) Do fertilisers help to make veld grazing earlier and later?

(8) What is the effect on the animals?

The experiments as a whole have not yet progressed far enough for anything but a preliminary report.

The nature of the experiments.

The minimum number of camps in any experiments is eight, and the usual size of each camp is one morgen, although there are some having only one-acre camps, and one with camps of two morgen each. The treatment of the camps was as follows:—O, P, PN, PNK, Ca, P. Ca., PN.Ca. and PNK.Ca. The treatments were randomised for the most part.

Treatment in lbs. per Morgen.

O=no fertiliser; P=400 lbs. equal quantities super and rock phosphate; N=200 lbs. sulphate of ammonia; K=80 lbs., chloride of potash; Ca=2,000 lbs. carbonate of lime.

It is planned to give the treatments yearly, excepting the lime, which would be applied only once in five years. Some experiments may get an extra dressing of 200 lbs. per morgen of nitrochalk ($15\frac{1}{2}$ per cent. N_2 and 48 per cent. $CaCO_3$) late in February or early March.

The fertilisers are spread on the ground in spring, usually after the first soaking rain, and the camps are then disc-harrowed where possible. The camps are grazed in rotation, which was not necessarily in numerical order but rather in that order in which they became fit to graze. Every camp must, however,

be grazed by the same animals in the one rotation. The animals are left in a camp for two to six days, depending on their number, its carrying capacity and the weather, and then moved on. There is one main group of animals rotating, but a second of followers is often desirable. Not more than two camps are used at the same time, including the one already grazed by the first line animals and having the followers. Records are kept showing the number of animals, their kind, age and sex, also the number of hours or days grazed in the camp. Observations are made on the condition of the grass, the state of the weather and the amount of rainfall. It is planned to visit the camps at regular intervals, to do the botanical analyses and take supplies for chemical analyses.

Results of experiments and observations.

(1) Data are given which show the carrying capacity of eight one-morgen fertilised camps rotationally grazed to vary considerably, depending on the composition of the yield and also the season. The records are confined to the periods September to June, and in many cases only from November to April. The carrying capacity based on twenty-four hour days for full grown cattle on eight one-morgen camps varies as follows:

5.4 cattle for 105 days
6.3 " " 151 "
6.2 " " 136 "
8.6 " " 70 "
11.5 " " 51 "
7.4 " " 112 "
17.0 " " 31 "
23.8 " " 58 "

and on the last camps later in the season, up to June, 13.8 for 45 days. In two centres twelve camps were used for sheep. One comprising only six morgen averaged 24.4 sheep for 222 days or 4 sheep per morgen, the other which had twelve one-morgen camps averaged 53 sheep for 101 days or 4.4 sheep per morgen, and later in the season averaged 54 sheep for 55 days or 5.3 sheep per morgen.

(2) The effect of fertilisers on carrying capacity is considerable, and nitrogen, phosphates, potash and lime all help to bring about an improvement, which is most marked in the case of nitrogen and phosphates. The substance which has shown up best thus far,

taking all the experiments into consideration, is nitrogen.

(3) Fertilisers appear to stimulate the growth of the more productive grasses, to decrease the amount of bare ground and to bring about other changes which will be discussed at a later date when more critical data are available.

(4) Animals show a marked preference for grazing the fertilised plots, and prefer the PN and PNK to the P, and the latter to the no-treatment.

(5) On the plots with PN and PNK treatments there is far less selective grazing, and even the unpalatable species such as *Elyonurus* have been well grazed.

(6) The fertiliser camps have stood the drought better, and their quicker recuperative properties after rain are most marked.

(7) As far as has been observed, fertilisers do not greatly affect the early grazing, as moisture is the limiting factor, except that after the spring rains the treated camps grow more quickly. In the autumn, however, fertilisers on rotationally grazed camps definitely prolong the grazing.

HALL, Thomas D. (4).

The procedure followed in obtaining grazing data, in this case cow days per morgen, from twenty-one experiments, in which grass is fertilised in various ways and grazed in rotation, is described. A comparison of the carrying capacity of fertilised and unfertilised camps is also made. The effects of these treatments on the botanical and chemical composition of the herbage are detailed, and also the observations of the co-operators and the writer regarding the favourable reaction on palatability and drought resistance recorded.

All the grazing records are summarised in Table I, which shows that the carrying capacity of the veld varies considerably in different localities. Improvement in carrying capacity up to 300 per cent. is recorded, and also the fact that it requires from 0.3 to 2.96 morgen to carry a beast under this system. The period during which the camps could be used varied from 47 to 268 days. On eleven of the experiments there was grazing available for 180 days and over. Grazing started as early as August in one

case, and in September and October in two other instances. Generally speaking grazing started only in November, and finished in April, May, and in eight cases, in June.

The fertilisers which gave the greatest benefit were phosphates and nitrogen—the benefits from the latter were manifested by greater bulk, and a darker green colour was particularly noticeable. Potash and lime also gave good results in many cases. The effect of these two substances in increasing the palatability over the improvement produced by P and PN was remarkable, so much so that in many instances the PNK and PNK.Ca plots were too closely grazed, and suffered accordingly in the succeeding drought. The striking effect of nitrogen in all these grass experiments is very different from the general experience of little improvement in using nitrogenous fertiliser on arable crops in the same soils, and the point is emphasised that farmers must realise that there are fundamental differences between fertilising arable and grasslands. The fertilised camps stood droughts better and also recovered from them sooner. This agrees with the observations of Richardson, Orr and Henrici as far as phosphates only are concerned; but even better resistance and recovery were obtained on the grass having PN, PNK and PNK.Ca treatments.

Fertilisers have definitely improved the chemical composition of the grass—up to 20 per cent. in crude protein, 57 per cent. in phosphoric oxide, 130 per cent. in potash, and 47 per cent. in lime, calculated on samples dried at 100°C.

Botanical analyses show that fertilisers have decreased the percentage of bare ground and undesirable grasses, and increased the percentage of desirable species. This again applies particularly to camps receiving nitrogen. Several graphs showing the effect of fertilisers on *Themeda triandra*, the most widely distributed of the better grasses, indicate clearly that this species increases under improved fertility conditions, and is notably responsive to nitrogen. *Eragrostis* spp. react to fertilisers in a similar way.

The data indicate that it may not be economically desirable to fertilise certain types of veld, when the more productive and desirable grasses do not occupy 18 to 25 per cent. of the area. Definite correlation

between the percentages of bare ground, better species of grass and cow days per morgen is shown, and also the relation of all three factors to different fertiliser treatments. Ample evidence is brought forward to show the beneficial effects of fertilisers on the nature of the herbage, its chemical composition and the amount of grazing produced. The beneficial effect of fertilisers in increasing palatability and drought resistance is also recorded.

MOSES, D. (5).

In order to provide grazing for their oxen and, at the same time, carry out some experiments with pasture grasses on the coast, Messrs. African Explosives and Industries, Ltd., laid down some large scale grassland experiments at Umbogintwini in March, 1931. A start was made on an area of $5\frac{1}{2}$ acres of sandy coast soil near the factory, which was laid out in 5 one-acre camps and 1 half-acre camp.

Kikuyu grass (*Pennisetum clandestinum*) being considered the most promising species for this area, it was planted in four of the camps. In one camp it was planted alone with clovers, in another with nine other grasses, mostly with the running habit, in the third with two indigenous running grasses and clovers, and in the fourth with a mixture of exotic grasses, including *Lolium perenne*, *Dactylis glomerata*, *Phalaris bulbosa*, and *Holcus lanatus*. The fifth camp was sown down to a mixture of 22 indigenous and exotic grasses and clovers, and the sixth to a mixture of Johnson grass, *Paspalum dilatatum*, exotic grasses and clovers.

Just prior to planting or soon after, the camps were fertilised with 300 lb. superphosphate and 100 lb. chloride of potash per acre. After the grasses were established or had germinated, 100 lb. sulphate of ammonia were applied per acre. Subsequently, 100 lb. sulphate of ammonia per acre were applied in October, 1931, and 100 lb. nitrochalk in January, 1932. During the first year, therefore, the camps received 700 lb. fertiliser per acre.

Good stands of kikuyu and other grasses and clovers were obtained, and during the first winter kikuyu and exotic grasses and clovers grew very well. In the dry period of early spring, however, the exotic grasses and

clovers died out, their place being taken by kikuyu in the kikuyu camps. In the exotic mixture camp, Rhodes grass, *Chloris gayana*, and two weed grasses formed the bulk of the grazing during the year. In the *Paspalum* camp, this species was practically the only grass in evidence at the end of the year.

Grazing was done in rotation, a span of 8 oxen rotating from camp to camp and remaining from 2 to 5 days in each camp according to the pasturage available. For most of the year from 2 to 7 mules and 1 horse were used as "followers," to graze down the tufts and rank patches left by the oxen.

It was found that mowing periodically could not cope with the accumulated matted growth of kikuyu grass, unless the camps were harrowed prior to mowing. Apart from an occasional harrowing and mowing, no other treatment was given.

The grazing records show that kikuyu grass has a high carrying capacity. According to these results the four camps which were predominantly kikuyu grass carried more than 1 head of large stock to the acre for ten months. The *Paspalum dilatatum* camp also showed up well, notwithstanding its somewhat open sward.

The results obtained during the period 1st August, 1931, to 31st May, 1932, are summarised in tabular form.

Samples of kikuyu grass were taken at monthly intervals for analysis. From July to April the analyses showed that a remarkably high feeding value was maintained, the average composition being 19.5 per cent. crude protein, 8.8 per cent. total ash, 6.9 per cent. silica free ash, 0.77 per cent. phosphoric oxide, 0.53 per cent. lime, and 3.02 per cent. potash. In protein, silica free ash, phosphoric oxide and potash content this grass is considerably higher than the average veld grass.

It is concluded that kikuyu grass is of considerable promise for the coastal belt, being aggressive, palatable, a running grass and, therefore, able to spread and fill in bare spaces, and of high feeding value and carrying capacity.

MOSES, D., and MCGILLIVRAY, I. H. (6).

An experiment involving the use of various fertiliser treatments on turf under

South African conditions is described. The effect of various fertiliser treatments on the pH of the soil is given, the method recommended by the International Society of Soil Science for the pH determination of soils being employed.

In all cases, ammonium salts increased the acidity of the soil. A pH of approximately 4.0 is suggested as the maximum acidity obtainable in this soil on treatment with ammonium sulphate.

A mixture of rock phosphate and superphosphate, when applied with sulphate of ammonia, had the same effect on the soil reaction as sulphate of ammonia alone.

No change in pH was observed on the addition of potassium chloride to the phosphate ammonium sulphate mixture.

The effect of lime in the presence of ammonium sulphate in decreasing the acidity of the soil layer from 0—6 ins but not in the layer 6—9 ins. was apparent.

Nitrate of soda was effective in reducing the acidity of the soil. After two years' treatment, the soil had substantially the same pH at all layers down to 9 ins. A pH of approximately 8 is suggested as a limit of alkalinity for the surface layer of this soil on treatment with nitrate of soda, potassium chloride and calcium phosphates.

The data obtained from grass cuttings, "turf values," and botanical analysis indicate

that the application of inorganic nitrogenous fertilisers is more important than any possible effect of variation in pH on the quality of the turf.

The dominant grass species, *Cynodon dactylon* Pers., is apparently able to thrive, other conditions being favourable, over a pH range of four units.

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PASTURE RESEARCH AT THE WAITE INSTITUTE.

The Director of this Institute, affiliated to the University of Adelaide, South Australia, [Prof. A. E. V. Richardson, M.A., D.Sc.] discusses the programme of pasture research at this Station in a paper, "The Mineral Content of Pastures. Report on Co-operative Investigations in progress at the Waite Agricultural Research Institute." [*J. Coun. Sci. Ind. Res.* Vol. 5. No. 3. pp. 141-51, 1932.]

The subject is treated under three main heads, (a) field investigations, study of mineral deficient areas, (b) factors affecting mineral content of pastures, and (c) factors affecting the water requirements of pasture plants.

Under the first heading are included the following questions:—

- (i) Effect of Soluble Phosphate on the Productivity, Stock-carrying Capacity and Chemical Composition of Natural Pasture at the Waite Institute.
- (ii) Effect of Equivalent Dressings of Phosphate as Water Soluble, Citrate Soluble, and Insoluble Phosphate on Natural Pasture.
- (iii) Effect of Phosphate on Natural Pasture in a Phosphate Deficient Region.
- (iv) Effect of Frequency of Cutting on the Productivity and Botanical and Chemical Composition of Natural Pasture.
- (v) Pasture Management Investigations.

- (vi) Growth of Pasture Plants on Mineral Deficient Soils.
- (vii) Pasture Survey of Mineral Deficient Areas.
- (viii) Pasture Technique.

In extending the scope of the original investigations, studies have been commenced on (a) pure species and pasture management, and (b) physiological aspects of mineral metabolism.

Manganese deficiency in soils has also been studied intensively.

Included in this report is a classified list of reports of the various sections of the investigation: this is reproduced here in its entirety.

A. Field Investigations—Investigations on Natural Pastures.

- (1) "Investigations on the Mineral Content of Pastures."—J. G. Davies, B.Sc., Ph.D., A. E. Scott, M.Sc., and K. M. Fraser, B.Agr. Sc.
- (2) "The Effect of Topdressing with Artificial Fertilizers on the Yield, Botanical Composition and Carrying Capacity of a Natural Pasture."—H. C. Trumble, M. Agr. Sc., and K. M. Fraser, B.Agr.Sc.
- (3) "The Effect of Superphosphate on Natural Pasture in a Phosphate Deficient Region."—J. G. Davies, B.Sc., Ph.D., and A. E. Scott, M.Sc.
- (4) "The Mineral Content of Pastures."—A. E. V. Richardson, M.A., D.Sc., Published as Pamphlet No. 17, C.S.I.R.
- (5) "The Influence of Frequency of Cutting on Natural Pasture in Southern Australia."—J. G. Davies, B.Sc., Ph.D., and A. H. Sim, B.Sc., B. Agr. Sc. Published as Pamphlet No. 18, C.S.I.R.
- (6) "The Experimental Error of the Yield from Small Plots of Natural Pasture."—J. G. Davies, B.Sc., Ph.D. Published as Bulletin No. 48, C.S.I.R.
- (7) "Composition of Pasture Species from various Regions of Australia."—A. E. Scott, M.Sc.

B. Sown Pastures and Pasture Management Investigation.

Species and Strain.

- (8) "The Role of Pasture Species in Regions of Winter Rainfall and Summer Drought."—H. C. Trumble, M. Agr. Sc., and J. G. Davies, B.Sc., Ph.D. *Journ. Coun. Sci. Ind. Res.* 4: 140, 1931.
- (9) "The Taxonomic and Agricultural Characters of the *Danthonia* Group."—A. B. Cashmore, B.Sc.
- (10) "Comparison of *Lolium perenne* and *Phalaris tuberosa* at varying Stages of Growth."—A. B. Cashmore, B.Sc.

- (11) "The Improvement of *Phalaris* Species by Selective Breeding."—H. C. Trumble, M. Agr. Sc.
- (12) "Preliminary Investigation of Indigenous Saltbushes (*Atriplex*) in an Area of Winter Rainfall and Summer Drought."—H. C. Trumble, M. Agr. Sc.
- (13) "The Nitrogen and Phosphoric Acid Content of Twenty Species of Pasture Plants at Fixed Growth Stages."—R. E. Shapter, A.A.I.C.

Pasture management.

- (14) "Seasonal Productivity and Botanical Composition of Irrigated Sown Pastures under varying Systems of Pasture Management."—A. E. V. Richardson, M.A., D.Sc.
- (15) "The Protein and Phosphoric Acid Content of Sown Pasture subjected to varying Systems of Pasture Management."—H. P. C. Gallus, B.Sc.

C. Factors affecting the Mineral Composition of Pastures.

- (16) "Factors affecting the Mineral Content of Pastures with Particular Reference to the Environmental Conditions incidental to Southern Australia."—A. E. V. Richardson, M.A., D.Sc., H. C. Trumble, M. Agr. Sc., and R. E. Shapter, A.A.I.C., Published as Bulletin No. 49, C.S.I.R.
- (17) "The Effect of Growth Stage and Intensities of Cutting on the Yield and Composition of a Perennial Grass—*Phalaris tuberosa*."—A. E. V. Richardson, M.A., D.Sc., H. C. Trumble, M.Agr.Sc., and R. E. Shapter, A.A.I.C.
- (18) "The Transpiration Ratio of Farm Crops and Pasture Plants in the Adelaide District."—A. E. V. Richardson, M.A., D.Sc., and H. C. Trumble, M. Agr. Sc. *Journ. of Agric. Sci. Aust.* 32: 224, 1928.
- (19) "The Water Requirements of Pasture Plants in a region of Winter Rainfall and Summer Drought and the Factors affecting the Transpiration Efficiency."—A. E. V. Richardson, M.A., D.Sc., and H. C. Trumble, M. Agr. Sc.
- (20) "The Relation of Mineral Ions to Transpiration."—A. H. K. Petrie, M.Sc., Ph.D.

D. General.

- (21) "The Rate of Growth of a South Australian Fleece."—K. M. Fraser, B. Agr. Sc. *Journ. Coun. Sci. Ind. Res.* 4: 204, 1931.
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HERBAGE AND FORAGE PLANTS

FURTHER NOTES ON TRIFOLIUM RESUPINATUM.

In the *Supplement to Herbage Abstracts* for September 1932, (p. 38-9) some information was supplied regarding the value of this legume in the Soviet Union. Dr. A. I. Belov (1) has also favoured us with considerable data regarding this plant, and as literature on the subject is rather scanty, his notes are being supplied in the present article.

Trifolium resupinatum, which is called "Kashkaut" in Soviet Central Asia or Shabdar in Persia, is cultivated to a large extent only in Transcaucasia (Azerbaijan and Armenia, mainly in regions adjacent to Persia) while in Soviet Central Asia it is of negligible agricultural importance, being confined to some villages near Bokhara.

SHABDAR IN SOVIET CENTRAL ASIA.

In pre-revolution times the experimental institutions of Soviet Central Asia tested shabdar with the hope of introducing it into cultivation on a large scale, but these attempts were unsuccessful. Shabdar requires much water, so precious in Soviet Central Asia, and in addition it is susceptible to fungous diseases; when cut, its hay does not dry simultaneously, with the result that either the valuable leaves are lost or its stems suffer from rotting when cut prematurely. These circumstances, together with the short duration of the trials with a very limited number of varieties mainly from Persia, caused the failure of the attempts to introduce the crop extensively into local agriculture.

The Central Plant Breeding Station at Tashkent, which is concerned among other problems with the selection of annual fodder crops and crops for the green manuring of cotton, has been and is still carrying out tests of some samples, mainly from Afghanistan and Persia, with the object of selecting varieties with a lower water requirement, higher resistance to disease, together with high yield when used for hay, and with an accelerated rate of growth under the lowest

possible temperatures when sown early in spring as a green manure for cotton. Under Tashkent conditions the samples from Hamadan, West Persia, were the most erect and productive, and have proved to be the most suitable. One of the Afghanistan samples appears likely to be quite acceptable as a green manure owing to its early ripening habit, but this strain is unfortunately deficient in yield owing to its smaller habit and fewer stems.

In most cases shabdar behaves under these conditions as an annual crop; sometimes plants were observed growing on into the following year, but these developed poorly during the second year as compared with the first and were usually killed off by mid-summer. It was not possible to select actual biennial plants from their offspring.

Shabdar has a root system which is very valuable from the point of view of its use in crop rotation, being fine and vigorously branched, penetrating to a considerable depth, and abundantly supplied with nodules.

The work at Tashkent has been confined to a superficial varietal study, but it is intended in future to study this crop more thoroughly from the agronomical point of view, in connection with the development of crop rotation in Soviet Central Asia.

Our correspondent advises us that there are probably no special publications on Shabdar, as he has found only a few isolated notes and chapters among other works on fodder crops. Among the more important literature may be mentioned Vavilov, N. I., and Bukinich, D. D. *Agricultural Afghanistan*. *Supplement* 33 to the *Bull. Appl. Bot.* pp. 610 (English summary, 535-610. 1929) in which is presented valuable information about Afghanistan shabdar.

N. N. Balashev's work, "Lucerne and Shabdar" (a report of field trials during the period of 1927-29, conducted at the Uzbekistan Experiment Station), was published in the synopsis issued by Narkomzem (National

Commissariat of Agriculture) of Uzbekistan S.S.R. (issue 3, 1930, Samarkand). In view of the exceptional value of the last-named work some of Balashev's notes on shabdar are cited :—

" Grows rapidly suppressing weeds, ... is of interest when sown in mixture with lucerne a large percentage of water content (85 per cent.) is its peculiar character difficult drying grows well on soils with high water table (50—70 cm) in spring the yield of dried hay is about 60—80 quintals for a summer season"

SHABDAR IN TRANSCAUCASIA.

Yanushevsky (6) states that work in the

humid subtropics of U.S.S.R. has been carried on only at the Sochi Experiment Station, while in the arid subtropics of the Transcaucasian S.F.S.R. the crop has been tested at different places with invariably positive results. The writer states that shabdar comes from Persia, where it is cultivated as an annual plant. According to N.I. Vavilov there are in Persia forms of shabdar which yield up to five cuts per season. In addition to its excellent fodder value and high yield, shabdar is a very suitable melliferous plant.

At the Sochi Station shabdar was sown on March 28th, 1914; some isolated flowers appeared on May 30th, while simultaneous flowering was recorded on June 11th. The following yields were obtained :—

Species.	Time of cutting.	Height of plant at time of cutting (in cm).		Weight of green forage.	Weight of air dry hay.
		maximum.	minimum.	in cwt. per ha.	in cwt. per ha.
<i>Trifolium resupinatum.</i>					
1st cut	 June 26	90	71	303.6	45.6
2nd cut	 July 18	45	35	149.8	37.6
3rd cut	 Sept. 24	45	35	48.0	12.0
Total.		..	..	501.4	95.5

These data should be regarded merely as preliminary as the test was carried out in small plots of about 200 sq. metres without replication. In addition there are no data concerning stand.

Trials with shabdar conducted at the Transcaucasian N.I. Kh. I. indicated that autumn sowings should lead to earlier flowering, which would make it possible to cut the crop at the beginning of May. In addition, autumn sowings, if done at the proper date, would produce vigorous bush formation thus also increasing the yield. In any case the Sochi data show that shabdar is of interest for the humid subtropics and hence properly conducted trials with this crop are essential.

In Gandzha experimental work with shabdar was commenced in 1926 in trials on crops to precede cotton. In this respect shabdar when harvested for hay has taken first place by causing an increase in cotton yield of 36.7 per cent. Breeding work on

material obtained mainly from seeds of a commercial shabdar mixture received from Persia through the courtesy of the Persian Growing Committee shows extreme diversity in this crop, which has not yet been subject to breeding. In this material a number of forms have appeared which represent among themselves a sequence with respect to hibernisation (ozimisation of Lyssenko), varying from typical winter to typical spring forms. In addition a large variety of forms was found varying markedly as regards tall habit, bush formation, foliage and rate of ripening. In the Breeding Nursery of the N.I.Kh.I. there were 1,166 forms of shabdar in 1930. Varietal testing was carried out with small plots, but the data, although showing a large range of variation, cannot yet be used for practical purposes. The crop was sown under ordinary field conditions in mid-October and on March 23rd; the former sowing wintered well and produced a hay cut of 29.6 cwt. per acre at the beginning

of May. The first cut of the spring sowing was delayed by six weeks and the second cut was harvested about mid-June; in addition a much lower yield was obtained.

It is of interest to note that late spring sowings not only delay, but may in certain forms inhibit flowering altogether if they are made too late in the spring. The author had an opportunity of confirming this when in 1928 a late shabdar sample was sown in mid-May; at the end of the season not more than 10 per cent. of the plants had flowered, i.e., only that part of the population which possessed a lower degree of hibernisation. Hence for most shabdar forms the best results were obtained by mid-October sowings. The high susceptibility to rust observed in 1930 should also be mentioned.

The suitability of shabdar for intermediate sowings in the mono-cultivation of cotton need not be discussed. In cotton-growing regions fallows can be used for this purpose as shabdar does not compete for water with cotton, since the first watering is applied to shabdar in October, the second at the end of March or beginning of April, and the third in mid-May, i.e., when cotton, provided that it has been sown at the proper time, requires no irrigation whatever. After its second cut shabdar may be ploughed under.

The trials at the Sochi Station indicated that shabdar might be of great value in the humid subtropics. All that is necessary is a change in the date of sowing. When sown in mid-October, shabdar under the influence of a moderate winter may produce its first cut about the end of April or the beginning of May, after which it may be ploughed into the soil and thus permit the sowing of the principal crop. Like peas, shabdar should be tested in the humid subtropics with respect to its productivity, rate of ripening and susceptibility to rust.

PRE-REVOLUTION LITERATURE ON SHABDAR.*

Shreder (5), who received some seed of *Trifolium resupinatum* which had been brought from Persia, reports on the botanical characteristics of the plant, describing the roots, stems, leaves, flower-heads and seeds.

Seeds of shabdar were sown at the research station both alone and with a cover crop of oats. The sowing under the cover crop was unsuccessful. The hay yield from a thick stand of this crop averaged 26.85 cwt. per acre, although its yield varied considerably according to the fertility and humidity of the soil. It is concluded that shabdar requires low-lying soils which preserve moisture well. Various other data regarding hay and seed are also presented. As regards the value of shabdar, Shreder concludes that it is an excellent fodder crop, palatable to cows and horses, and possessing high nutritive qualities. The soft stems of this plant make it superior to lucerne as a fodder and also superior to red clover owing to the absence of hairs. It is also markedly superior to *Trifolium incarnatum*. In using shabdar as a green manure it is suggested as expedient that two hay cuts should be taken and the third used for ploughing under. This must, however, be obtained before the late autumn since *Trifolium resupinatum* is not frost-resistant. A suitable green manure plant which would resist the cold of October or even November is *Vicia villosa*. Shreder considers that shabdar is eminently suitable to fill the gap existing among the leguminous fodder crops which can be used in a simple and not too prolonged crop rotation. Lucerne with its perennial habit is unsuitable for this purpose. Red clover [*Trifolium pratense*] is more suitable, giving excellent results on land of good fertility. Shabdar is valuable in that within one season it yields all that can be expected from a leguminous fodder crop. It may be used in 3-course and 4-course crop rotations of the following types: (1) cotton, (2) shabdar, (3) wheat; (1) cotton, (2) spring wheat, (3) shabdar, (4) winter wheat. (A full translation of Shreder's article is available on request.)

Bushuev (2) reports that shabdar was sown on the 5th March, germinated on the 11th March, flowered on the 28th May, and flowered a second time on the 16th June. After the second cut, taken on the 18th June, the stand was depleted, forming aftermath slowly, lodging and giving a small third cut on the 20th July and a fourth cut

* Probably all the dates are given in the Julian calendar which was officially used in Russia before the Revolution of 1917.

on the 28th August. Part of the shabdar sowings survived the winter in spite of the severe frost, and continued to grow on into the following year, although shabdar is generally considered to be an annual plant.

The yield of green fodder per acre was as follows:—

1st cut	156.3 cwt.
2nd „	135.9 „
3rd „	66.1 „

while the dry weight obtained for the three cuts was about 61.3 cwt. i.e. it was not inferior to old lucerne. (*Fuller details are also available from this paper.*)

Korzik (3) reports as follows:

Shabdar (sown first in 1909).

Sowing:	Feb. 23.
Germination:	Apr. 5.
1st leaf:	Apr. 11.
1st irrigation:	May 1.
1st cut:	June 4.
2nd cut:	July 13.

The crop was later burnt up by the sun probably owing to absence of irrigation. The figure of 51.95 cwt. per acre is given as the total of two cuts (probably dry weight).

Trials in 1910:

Sowing: March 8.

Germination: March 14. (15-16 March heavy rain induced crust on soil).

1st leaf: March 27.

Flowering: June 1.

1st cut: June 18. 11.67 cwt. of dry hay per acre:

after which date shabdar was scorched and suppressed by weeds.

Thus the writer concludes that in spite of the excellent quality of its hay as regards aroma, softness and palatability, shabdar does not come up to expectations as a biennial

crop. Even as an annual crop it has not proved quite satisfactory, when compared with lucerne, which under similar conditions gave an average in one cut of about 30 cwt. per acre. Similar results were obtained in 1911 and 1912.

Mukhin (4) reports as follows:

Sowing: March 30 (at the rate of 13.48 lb. per acre).

Germination: April 9.

Flowering: June 16.

1st cut: June 28. 22.5 cwt (of dry hay probably) per acre.

2nd cut: 19.93 cwt. (of dry hay probably) per acre.

3rd cut:

Irrigation: 4 irrigations before 1st cut, 3 irrigations after 1st cut and 3 irrigations after 2nd cut.

In the report for 1912: "Shabdar giving for two cuts 409.93 cwt. of green mass proved to be the most productive."

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SEED PRODUCTION IN SCANIA, SOUTH SWEDEN.

W. Weibull, writing on the earlier phases, present position, and prospects of Scanian seed production* discusses the various crops and the extent to which they are used for this purpose.

HISTORY AND TECHNIQUE OF SEED PRODUCTION.

Red clover [*Trifolium pratense*].

For many years Sweden has possessed a number of strains of red clover nearly all of the late or medium-late type. Scania has one such strain—Spannarp clover. This strain is hardy, comparatively resistant to stem rot and eelworm, but under unfavourable harvesting conditions the seed frequently is shrivelled and slightly discoloured. Another strain of red clover which has become very popular during recent years is the so-called Harrie strain. This gives better seed, but is perhaps not so resistant to stem rot and eelworm. There are in Sweden other strains which are as high-yielding and as winter-hardy as these two Scanian strains. Late red clover has not been in such general use in Scania, the foreign "two-cut" type being considered more suitable for that district. It has, however, been found that the foreign red clover is more susceptible to stem rot and eelworm attack. The realization of the fact that the one-year ley is not economic, and should be converted into a two-year ley also favoured the utilization of late clover. In the second year's ley, late clover makes a much larger contribution to the yield than does the foreign clover, which by that time has frequently disappeared completely. The import of seed of "two-cut" red clover at present amounts to approximately 5,000 sacks. Sometimes late Swedish clover is sown with early foreign clover. Cutting is carried out when the earlier clover is coming into flower. The quality of the hay from a mixed plot of this kind is better and the aftergrowth of pasture is equally abundant. Finally the two-years ley is richer in clover than if only foreign red clover had been sown.

In recent years also, improved earlier strains have been produced which in addition to giving a higher yield are more resistant to stem rot and eelworm than the ordinary foreign red clover.

In Sweden there has for a long time been a duty of 20 öre (öre=ca. $\frac{1}{8}$ d.) per kg. on clover. This amounts to approximately 100,000 kronor (krona=ca. 1/1) a year for South Swedish agriculture (as stated above about 5,000 sacks are imported).

Seed production of late red clover has been carried on extensively in Sweden for many years. Thus Swedish requirements of seed of late clover can generally, indeed practically speaking always, be satisfied by means of home-grown seed. Recently too a small quantity of late clover, about 2,000 sacks a year, has been exported. It has found its way into Denmark and the other Scandinavian countries as well as to other countries, including England.

Alsike [*Trifolium hybridum*] is a Swedish cultivated plant originating from the parish of Alsike in Uppland. A large amount of alsike is used in Scania in the cultivation of leys. On the other hand seed production of this variety of clover is not carried on to any great extent in this district. Seed production is localized in Middle Sweden, for the most part in West Östergötland. Swedish alsike is well known in the export market. It is much higher yielding and much more reliable in cultivation than Canadian alsike. Alsike seed produced in Sweden is purchased by the other Scandinavian countries and also by Germany. Seed production of alsike is also practised in other parts of Europe, particularly in Latvia and Lithuania. The seed from these countries gives nearly as high a yield as the Swedish seed. To protect the Swedish strains there has as a matter of fact been in force recently a prohibition of the import of alsike seed. The amount of seed of this species exported annually by Sweden varies from 3,000 to 6,000 sacks.

* Skånska fröodlingen, dess tidigare skeden, nuvarande ståndpunkt och dess framtidsutsikter. [Scanian seed production, its earlier phases, present position and prospects.] By W. Weibull. *Svensk Frötidning*, 1, pp. 119-25. 1932.

White clover [*Trifolium repens*].

Very variable types of white clover are to be found. Some of these such as Morsø and Strynø are outstanding. They are hardy and give a considerably higher yield than ordinary commercial seed. Abundant supplies of seed of these strains are now available. Thus the question arises as to how far it would be possible by means of prohibition of import to exclude the ordinary commercial seed. The Strynø strain sets seed more unevenly than Morsø which, therefore, is the better type for seed production. Breeding work is being carried on at Weibullsholm and has as its object an improvement in the yielding capacity of the strains and in their ability to spread. In breeding it is of importance to pay attention to the seed setting capacity of the new strains. This varies in a very high degree. Some strains have longer flower-stalks than others and have too a more marked capacity for flowering simultaneously; they are, therefore, more suitable for seed production. Import amounts to 600—700 sacks.

Lucerne [*Medicago sativa*]. Lucerne is a meadow plant which, at least with the strains at present available, is not suitable for seed production in Sweden. It requires a higher temperature and above all a drier climate. Under Swedish conditions it may possibly be improved and grown as stock seed. Reproduction must take place abroad. About 700 sacks are imported annually.

Medicago lupulina. Seed of *Medicago lupulina* is produced in Sweden, particularly in Gothland. In Scania too an attempt has been made to produce seed of this species. *M. lupulina* is, however, not extensively used either in leys or for green manuring of stubble-fields. Seed is cheap as a rule and the supply in Gothland good. Seed production of *M. lupulina* is not considered particularly profitable.

Sowing in drills with the drills far apart has not become general for the clover species, except possibly in the case of white clover.

Meadow grass.**Timothy** [*Phleum pratense*].

Timothy is one of Sweden's most important hay grasses. Seed is produced in

various districts, also in Scania and there perhaps mostly in the interior of the province of Kristianstad. In seed production the timothy seed is as a rule sown in a mixture with seed of red clover. In the first or second harvest year the ley is cut for fodder, afterwards it is put up for seed for 1 to 2 years. Recently, the timothy drills have been sown further apart, facilitating the control of certain weeds such as *Matricaria inodora*, ox-eye daisy and others. By sowing the seed with the drills far apart seed production is extended over a longer period. According to the writer's own experience, the straw is stiffer with a greater distance between the drills, and the amount of nitrogen applied can be increased considerably. Great care is necessary in threshing. The speed of the cylinders must be reduced, and if this is done the percentage of hulled seed can generally be easily kept below 10.

Cocksfoot [*Dactylis glomerata*.]

Seed production of this species has been practised for many years in Denmark; recently it has been taken up in Sweden. Usually the drills were sown 45—60 cm. apart, but now they are sown closer together, for example, 20 cm. apart. Cocksfoot sown with the drills closer together gives quite as high a yield of seed, at all events during the first year that a seed crop is taken. The ley is cut for fodder the first year, and seed is taken for one or two years subsequently. Sowing in drills with a greater distance between the drills extends the period of seed production, but the tufts which appear when the cocksfoot ley is ploughed up are very difficult to deal with. Cocksfoot is a stiff-strawed grass and can, therefore, endure heavy applications of nitrogen. Urine is frequently applied to the ley.

Perennial rye-grass [*Lolium perenne*], **Italian rye-grass** [*L. italicum*], and **Field brome grass** [*Bromus arvensis*.]

Perennial and Italian rye-grass and also field brome grass are grown generally speaking as one-year seed cultivations, the seed crop being taken the first harvest year. They are then sown pure and not in a mixture with clover. Sometimes a perennial rye-grass plot is grown for a period extending over several years. At Svedberga two-year seed

plots have proved successful. In sowing the rye-grasses, the drills are usually close together. For field brome grass broadcasting is the better method. Stock seed of this species must be treated with warm water to prevent smut: the temperature should be 55—56°C.

Meadow fescue, perennial and Italian rye-grass, and soft brome grass are not stiff-strawed varieties. Applications of nitrogen should, therefore, not be too heavy.

Pasture grasses.

Rough-stalked meadow grass [*Poa trivialis*].

This species is grown as a rule as a one-year cultivation. Up to the present, seed production has not been carried on in Sweden on a large scale.

Red fescue [*Festuca rubra*], smooth-stalked meadow grass, [*Poa pratensis*], and fiorin, [*Agrostis alba*].

Red fescue and smooth-stalked meadow grass are gaining ground in pasture cultivation. The method of seed production of red fescue is similar to that of meadow fescue. Red fescue has weaker straw than meadow fescue, so that caution must be exercised in applying nitrogen. Seed production of this species has been successfully carried out at Spargodt and Svedberga.

Seed production of smooth-stalked meadow grass and fiorin (*Agrostis alba*) is, however, more difficult. There are plots of these species at Lönhult and Axeltofta with drills 45 cm. apart. The writer has not yet had sufficient experience to allow of his expressing an opinion concerning the possibilities of seed production of these species in Sweden.

Nitrogen is applied to grass seed plots in the form of saltpetre and sulphate of ammonia. The writer has found sulphate of ammonia very satisfactory, at least considering present prices. In applying the nitrogen one-third should be used in the autumn, in September, and the remainder in the spring, in March, or at latest in April.

Present position and prospects.

In recent years Sweden has exported about 2,000 sacks of red clover, 3—6,000 sacks of alsike and 3—4,000 sacks of timothy. Particularly in the case of alsike has

the amount exported been large in proportion to the amount of seed grown, which is about 20,000 sacks. The amount of timothy seed exported has also been large, but, however, not so large in proportion to the quantity produced, about 50,000 sacks. Red clover and to an even greater extent alsike are Swedish products well known abroad. Weibull considers that much could be done to increase the sale of alsike in England and also in Germany. For the rest he does not believe that the sale of alsike will be more difficult this year. Certainly there is a reduction in the amount of red clover bought by Denmark, as that country will soon be self-supporting as far as this species of seed is concerned; but England is still a good customer. With regard to alsike, Sweden's most dangerous competitors, the Baltic countries and Canada, are not to be very much feared this year. The quality of Courland alsike is said to be not good and the price of Canadian alsike stands high in comparison with Swedish seed. The seed harvest of alsike appears to be very abundant in Sweden, but as Sweden is the only country where this would seem to be the case, export should present no difficulty.

The yield of timothy is not as large this year as last. Possibly the areas have been reduced as a result of the marked fall in prices last season. At present the price is very low, about 55 öre per kg. If prices do not improve later, it would certainly be better to restrict seed production of this species somewhat.

Generally speaking, the amount of seed of the other species of grasses imported into Sweden is in excess of that exported. Meadow fescue, however, is an exception, Sweden's requirements of this species being met by home-grown seed. Cocksfoot and meadow fescue, which before the war commanded good prices, about 1 krona per kg., now realize only about half that price wholesale. The same applies to Italian rye-grass and field brome grass, as the price of these two species has fallen considerably. There has been a very great fall in the price of perennial rye-grass also. Denmark ought to reduce its seed production areas. Up to now Sweden has only been desirous of satisfying her own requirements. Transactions with all these species of grass seed are conducted mainly just within the south of

Sweden, that is, in Scania, Halland, Blekinge, Gothland and Öland. That the sale of seed has been rendered more difficult is, however, also due to another cause. Certain countries have more or less closed their markets; for example, export of cocksfoot to the U.S.A. is almost impossible now. Trade with other countries, such as Russia, is at a standstill. Seed production is carried on at a loss. Where before the war gross receipts were about 250 — 300 kronor per Td. Ld. (*Tønde Land* = ca. 1.36 acres) they are now only half that amount, and the costs of harvesting are not lower but higher. The difference in value of the crop referred to here is not less than about 100 kronor per Td.Ld. If nothing is

done to assist seed production of the grass species mentioned above, growers will find it to their advantage to give up seed production and to turn their attention to other crops which are protected by the State, instead of risking greater losses in competition with the free trade country of Denmark. The writer points out that the price of wheat in Denmark is about 11 öre per kg., while in Sweden it is 16 öre per kg. There is the same difference in the price of rye. The price of barley also is lower in Denmark than in Sweden. It is, therefore, of little avail to strive for the continuation and extension of seed production unless assistance is given by the State.

ANNOTATIONS

Soviet Agricultural Botany Research.

With the aid of two maps, of European and of Asiatic Russia respectively, Dr. F. Merckenschlager* indicates the manner in which existing and projected Agricultural Botany Research Stations are disposed in the U.S.S.R. For plant breeding purposes the Union is divided into fourteen regions, of which the central, humid region (Moscow, White Russia) is that in which the breeding of herbage plants is chiefly concentrated. Lupins and serradella are bred in this region also. In the remaining regions the following objects of investigations may be of interest:

Region.	Crop studied.
Sub-arctic, Baltic.	<i>Phleum pratense</i> , <i>Trifolium pratense</i> , <i>T. hybridum</i> , <i>Pisum</i> , <i>Vicia</i> , <i>Lupinus</i> and <i>Phaseolus</i> , the object being to obtain early forms in annuals and winterhardy forms in perennials.
North-eastern region.	<i>Pisum</i> , <i>Vicia</i> and <i>Phaseolus</i> .

Transition zone of the Upper Volga.	<i>Helianthus</i> , <i>Lens</i> .
Black soil region.	<i>Pisum</i> , <i>Lens</i> , <i>Helianthus</i> .
Forest steppes.	<i>Glycine</i> , <i>Medicago sativa</i> , <i>Trifolium</i> , <i>Onobrychis</i> , <i>Pisum</i> , <i>Lens</i> and <i>Vicia</i> .
Steppes (Ukraine, Krim).	<i>Andropogon sorghum</i> var. <i>sudanense</i> , <i>Helianthus</i> .
Arid region of the Lower Volga.	<i>Helianthus</i> .
Western Siberia.	<i>Medicago sativa</i> , <i>Onobrychis</i> , <i>Melilotus</i> , <i>Pisum</i> , <i>Phaseolus</i> , <i>Lens</i> , <i>Helianthus</i> .
North Caucasian sub-tropical region.	<i>Helianthus</i> .
Transcaucasian region (Georgia, Armenia).	<i>Glycine</i> .
Turkmenian region, Central Asia.	<i>Medicago</i> .
The Far East.	<i>Glycine</i> and <i>Helianthus</i> .

*Das russische landwirtschaftlich-botanische Forschungsnetz. (The network of agricultural botanical research in Russia.) *Züchter* 5. 44-6. 1933. (Biolog. Reichsanst., Berlin-Dahlem.)

Turkestan Alfalfa Seed.

It is noted in *Seed World* [Vol. 32. No. 12. pp. 9 and 28, 1932] that officials of the Bureau of Plant Industry of the U.S. Department of Agriculture considered a plea for staining seed from this source a distinctive colour, in order to indicate its adaptability for use in certain parts of the United States.

Mr. H. L. Westover showed that this seed is less productive than the domestic strains, but that it is more resistant to wilt, although it is very variable in this respect. It is doubtful whether this resistance superiority is sufficient compensation for the lower yield per acre.

Technique of pasture investigations.

A Bulletin on this subject, containing contributions from various research workers in the British Empire, is in preparation and will be sent to press as soon as all the contributions have been received at the Bureau.

Breeding of meadow plants.

A non-current paper of which a translation is now available to subscribing countries is "Resultat och önskemål vid vallväxtförädlingen" [Results and desiderata in the breeding of meadow plants] by Nils Sylvén, Kungl. Landbruks-Akademiens Handlingar och Tidskrift, 1930, p. 513.

Fortschritte der Botanik.

This new botanical review, edited by Fritz von Wettstein, München. contains articles by competent German authorities on the progress of the accumulation of knowledge during recent years in all parts of the world in the following branches of botany.

- A. Morphology.
- B. Systematics and strain studies.
- C. Physiology of metabolism.
- D. Physiology of organ formation.
- E. Ecology.

It is published by Julius Springer, Berlin.

Probable contents of the June number of *Herbage Reviews*.

It is hoped to prepare or to receive contributions under the following heads :

- (1) Pasture research and practice in Finland.
- (2) Soybean investigations in the United States.
- (3) German seeds mixture calculations.
- (4) Contributions from U.S.S.R. on vernalisation.
- (5) Details of the international test of lucerne ecotypes.
- (6) The format of German pasture books.

Also other items.

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